THE GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF

MINNESOTA.

THE FIFTEENTH ANNUAL REPORT

FOR THE YEAR 1886.

N. H. WINCHELL, State Geologist.

Submitted to the President of the University, May 1st, 1887.

ST. PAUL:
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1887.

ADDRESS.

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, May 1, 1887.

To the President of the University,

DEAR SIR: I herewith communicate the fifteenth annual report of progress of the geological and natural history survey of the state.

With great respect,

Your obedient servant,

N. H. WINCHELL,

State geologist and curator of the general museum.

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GENERAL CONTENTS.

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REPORT.

I.

SUMMARY STATEMENT.

As intimated in the last report, the field work was renewed in 1886, in the northern part of the state. Three parties, organized and equipped for geological observations, were set at work with headquarters near Tower, on the south shore of Vermilion lake. These were under the personal direction of Dr. M. E. Wadsworth, of Waterville, Dr. A. Winchell, of Ann Arbor, and myself. From a central supply camp they were sent out on trips designed to occupy a couple of weeks each, more or less, returning for supplies and to deposit and ship the specimens they had collected, at the end of each trip. At the same time a party of botanists, under the direction of Prof. J. C. Arthur, scoured the country about Tower, for plants, both phænogamous and cryptogamic, making a large collection.

It was found, however, as the season advanced, and owing to the health of Dr. Wadsworth, that it was necessary to vary from the plan with which the work opened. The distance from the base of supplies kept increasing; and on account of the great difficulties of travel, and the time consumed in getting back to Tower, it was found desirable to move the supply camp to a point about forty miles further east. This was on the south shore of Fall lake, at the mouth of the Kawishiwi river. The fatigue and hardship being too great for Dr. Wadsworth's health, he was relieved of field work, and was given a systematic microscopic examination of some of the igneous rocks of the northern part of the state, of which many thin sections had already been made by the survey. This occupied him during the rest of the season, the work being done in the laboratory of the survey at Minneapolis. While this weakened the force in the field it did not retard the actual progress of the survey, since this microscopic work had to be done on this group of rocks. In a

measure, Dr. Wadsworth's place in the field, at the head of one of the parties of observation, was supplied by so arranging the minor excursions that one of them could be conducted by some of the younger geologists.

The number of men engaged, at different times during the season, including the botanists, varied from eight to fourteen. The names of the gentlemen connected with the scientific field work during the season are as follows:

N. H. WINCHELL, generally assisted by Mr. U. S. GRANT who also made collections of fresh-water shells, and notes on the avi-fauna, for Dr. P. L. Hatch; but in the fore part of the season assisted by Mr. H. V. Winchell.

A. WINCHELL, generally assisted by Mr. F. N. STACY, but assisted in the fore part of the season by Mr. A. W. JONES.

M. E. WADSWORTH, assisted, while in the field, by Mr. U. S. GRANT.

Some independent observations were made, on short trips, under the direction of Messrs. H. V. Winchell, Stacy and Jones.

J. C. ARTHUR, assisted by L. W. BAILEY, JR., and E. W. D. HOLWAY; also by Mr. A. W. JONES.

Each party consisted of three men — the geologist who devoted himself entirely to his note book, instruments, township plat and specimens; his assistant who was always ready to carry specimens, dress out rock samples, or serve his principal in any way needed, but when not so occupied was expected to lend his hand to the camping, canoeing or cooking, and an expert woodsman or voyageur who was familiar with the traveled routes and the geography of the region. These three, with their impedimenta, would comfortably fill the ordinary birchen canoe of the Indians, by means of which all such traveling has to be done in the region examined.

The geologists were on the ground a little after the first of July, although the permanent camp was established and some field work was done before the fifth of June. The party returned to Minneapolis about September 20th. The extra expenses for the season's field work reached nearly $3,500, but this included the purchase of some apparatus and material which will be of use another season.

The report of Dr. A. Winchell, on his work on the crystalline rocks in the northeastern part of the state, is included in the following pages. This embraces a profusion of detailed obser-

vations, followed by some generalized statements on the stratigraphy, and will be of value in the future study of the systematic geology of this great series of rocks.

The report of Dr. M. E. Wadsworth on the microscopic examination of some of the igneous rocks of the state, though one of the important results of the year's work, will be issued as a bulletin, separate from the report of progress, according to the terms of a law of the late legislature entitled *an act to extend the work of the geological and natural history survey.*

Prof. Arthur's report of progress on the botany of the state, including observations by himself and Messrs. Bailey and Holway, and a contribution by Mr. Warren Upham, will also be issued as a separate bulletin. Very substantial and important advance was made in the botanical department of the survey by the work of last season, and large additions were made to the survey herbarium.

In a similar manner Mr. Oestlund's current report on the Aphididæ, being a systematic memoir on the family, will be delayed temporarily in order that it may embrace the observations and study of another season, and will appear as a bulletin of the same series.

Prof. C. L. Herrick has submitted a large part of his final report on the mammals of the state, but a portion of it remains still in his hands. As soon as it can be completed it will be put to press.

Dr. P. L. Hatch is still engaged on his final report on the ornithology of the state, and is bringing it to a close as rapidly as possible. It is intended to include it with Prof. Herrick's on mammals, in one of the final volumes of the survey report.

Numerous accessions have been made to the museum collections, and to the material which represents the field work of the survey. The latter, in the main, are not entered in the regular museum lists which follow, but are registered by another series of numeration and reserved for further study. The cases that are designed for the exhibition of specimens are full, and the rooms containing them are not large enough to accommodate any further display. It is hoped earnestly that ere long the museum may be removed to better quarters with ample accommodations.

The printing of vol. II of the final report has been unwarrantably and culpably delayed by the contractors. At this date (April 15, 1887) the manuscript has been in their hands nearly twenty-one months, and without any justifiable excuse for delay

with continual urging and remonstrance on my part, met with voluble and reassuring promises of immediate action on theirs, they have not yet completed the first two chapters, and have lithographed but two of the plates. At the rate at which the work has progressed during the past two years, it will require more than twenty years before the volume is issued.

The following report is taken up very largely with the geology of the iron-bearing rocks. Within the past two years a great interest has been awakened in the iron industry in the Northwest. The success of the pioneer company, the *Minnesota Iron Company*, has attracted general attention to northern Minnesota as an iron-producing country, and numerous inquiries are made for some information, as full and authentic as possible, on the geology of these rocks, and for maps giving their distribution. It is with a view to supply this demand, as amply as the survey is able at present, that this character is given to this report.

It should be understood that the tentative conclusions which the observations of the season have seemed to warrant, respecting the stratigraphy and genesis of the rocks of this part of the state, so far as they are expressed in this report, are merely tentative, and are given in order to group the observations into some systematic scheme, to make the details somewhat more intelligible by the reader. They are intended to express the most apparent and ready explanation of the facts. The mineralogical determinations are only such as were made in the field, there having been no opportunity to study the specimens with greater care, nor even to open the boxes in which they were packed.

The name *Vermilion group* as used in the following report is intended to include a portion of the complex series of schists which in the late report of the Canadian geological and natural history survey has been designated *Kewatin series*, by Mr. A. C. Lawson. It embraces the mica-hornblendic schist rocks that appear at the northwest extremity of Vermilion lake, and their equivalents at the west end of Birch lake as well as their extension eastward from Vermilion lake to Basswood lake. This group lies between the graywackes on one side and the basal syenites and granites on the other, thus covering only the lower portion of the *Kewatin series*.

II.

REPORT OF A. WINCHELL.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

N. H. WINCHELL, STATE GEOLOGIST.

REPORT

OF

GEOLOGICAL OBSERVATIONS

MADE IN

NORTHEASTERN MINNESOTA

DURING THE SEASON OF 1886.

Accompanied by a Geological Map and 57 Structural Illustrations.

BY ALEXANDER WINCHELL,
PROFESSOR OF GEOLOGY AND PALÆONTOLOGY
IN THE UNIVERSITY OF MICHIGAN.

(Part II of the Annual Report of Progress for 1886.)

ST. PAUL:
PIONEER PRESS COMPANY.
1887.

CONTENTS.

LIST OF ILLUSTRATIONS.

REPORT OF A GEOLOGICAL SURVEY IN MINNESOTA DURING THE SEASON OF 1886.

By Alexander Winchell.

1.—PRELIMINARIES.

The region reported on. The writer submits a report of geological field-work done during July, August and September, 1886, under instructions from the state geologist of Minnesota. The region examined lies in the northeastern portion of Minnesota, north of the western part of lake Superior. It stretches in a direction north of east from Vermilion lake to Knife lake and Ogishke-Muncie lake and somewhat beyond. It lies between ranges 5 and 15, west, and towns 62 and 66, north—extending into twenty-four different townships. There are no public roads within the region, and it can scarcely be said that the least improvement for facilitating travel has ever been made by public authority. Not over half a dozen settlers were seen in all the region, and these were located in the cheapest log cabins, where the time was spent in awaiting the maturity of their titles to the legal allowance of land and in looking up pine districts and iron-ore locations. Not a single Indian was found resident in the district, and only about four square rods of soil were found cultivated.

Means of communication. The exclusive mode of travel and transportation is by birch bark canoes of Indian manufacture. A canoe 16 to 18 feet in length will carry three men and the requisite baggage for camping, provisions and work. Between the lakes portages are made, the canoe being transported by itself, generally on the head and shoulders of one man, and the baggage being separated into as many bundles as necessary. The portages over the routes most traveled are from a quarter of a mile

to more than a mile in length. They are simply winding footpaths leading by the nearest practicable route over plains and rocky hills and across swamps and bogs. The best have at some time been cut out sufficiently for the transportation of the canoe, but the portage trail consists chiefly of a path more or less beaten by long continued Indian travel. On some of the principal trails the path is in places deeply worn, but always narrow. On other trails the marks of travel are so obscure that much difficulty arises in picking the way. The work of the past season rendered it necessary to traverse 123 portages, having a total length of 43 miles.

In the region east of Vermilion lake, the principal routes of communication are between the east and west. The direction has been determined by the location of the chief Indian settlements; in the east about Beaver bay and Pigeon river, and in the west, from Vermilion lake to the upper Mississippi and beyond. However, more fundamental than the location of settlements, was the disposition of the great natural features of the country, which predetermined the trends of most practicable communication. Thus the situation of the interior lakes rendered travel between east and west vastly easier than between north and south. From Vermilion lake eastward the great thoroughfare may be described as follows: At the northeastern corner of Vermilion lake, the route passes to the head of Mud Creek bay, and thence through Mud creek, including a portage, and two Mud lakes, thence by portage to Burntside lake, thence by portage to Long lake, and thence to Fall lake. From the eastern extremity of Fall lake is a route over the rapids northwards into Basswood lake, and another by portages into another arm of Basswood lake, and along the national boundary eastward, leading across the portage into Carp lake, and the succession of waters toward Knife lake; from Fall lake is another principal route, leading by portage to Garden, Farm and White Iron lakes. The portages will be particularly noticed in the following report, and will be found properly located on the accompanying map.

Not a little surprise has been experienced that the principal portages have been left so long without improvement at the hand of civilization. Tower is a settlement of two or more thousand, and transacts a considerable business with regions lying to the eastward. Hunters, settlers, explorers and Indians must find exit eastward over these portages and must transport all their provisions and other supplies over them. Everything

destined for Tower must be got over these portages. One would imagine a town so dependent on facilities of exit and approach, would seek to improve its highways. But the very first portage, within six to eight miles of Tower, is one of the most execrable in the region; and when the water is low the difficulties of the transit through Mud creek are very great. Then the portage also from Mud lake to Burntside is obstructed by logs, rocks, loose stones and a long stretch of scarcely passable marsh. Five hundred dollars would put this portage in a condition suited for civilized transit. Two hundred dollars would suffice to lay one or two stretches of hewn logs across this swamp. As these lands are largely public lands, the subject of improvement of transportation would seem to be a legitimate one to bring to the notice of the public authorities, either of the United States, the State or the County.

The inland lakes. The country through which these explorations have extended is dotted by numberless small lakes, separated from each other by intervals varying from a quarter of a mile to two miles. All the larger lakes present an elongated form, having a length two, three or four times their breadth. The longer axis trends generally north of east, in conformity with the rocky structure which has determined the forms and positions of the lakes. Their shores are generally rocky, and rise to altitudes of 10, 15 or 20 feet; though in occasional instances the cliffs attain elevations of 50 to 80 feet. Some portions of the shores are covered by a thin sheet of drift material, or more generally by the angular débris and earthy products of atmospheric destruction. In portions of the district the outcropping rocks are mostly bare, but in others they are covered by a dense cushion of mosses. It is probable that in regions where the original forest has been burned, the mosses have been removed by fire or destroyed by exposure to the rays of the sun.

Character of the report. The general results of the observations of the past season can not at present be fully formulated, for the reason that the general views to be entertained respecting any portion of the region depend partly on observations extended over the whole region—from Vermilion lake to Thunder bay. That region is a unit, and each part must be interpreted in the light of the whole. It is impossible, therefore, to offer a concise digest of conclusions. The attempt, likewise, to offer a digest of the facts as far as observed would simply rob the reader of a portion of the data requisite to form his own provisional conclu-

sions. With the knowledge that more or less of the facts are kept back, the reader would feel compelled to hold even provisional conclusions in abeyance; and in fact might well feel that the consideration of a portion should be postponed until the presentation is made complete. Were the details of fact destined to appear in a final report, their appearance is likely to be delayed for an inconvenient period; while the questions presented by the geology of the region possess immediate and living interest. But it is even doubtful whether the full details will be admissible in a final report. It has seemed, therefore, on consideration, that this is the time and place to offer a full statement of the facts as observed.

These facts will be grouped about the principal lakes of the region rather than thrown in the form of an itinerary. The facts thus, which are geographically related to each other, will be brought into juxtaposition with each other and with the great natural features of the country. This will aid in the mastery of the subject, and facilitate future reference.

Following these details, however, will be a general summary intended for the use of the more casual reader.

Locality numbers. The references to the localities are precise, designating not simply the square mile but the particular forty acres on which the observation is made. Each locality, moreover, receives a special serial number, and is briefly referred to as "Halt" so and so. In designating localities the usual formula of the land surveys is employed; but to obviate unnecessary repetition, the terms "township" and "range" are omitted, since the "township" is always "north," and the "range" is always (in this report) "west" of the "fourth meridian, Minnesota." Thus, "N. E. ¼, S. E. ¼, S. 8, T. 62-11," designates a certain "sixteenth" in section 8, of township 62, north, in range 11 west, of the 4th meridian, Minnesota.

Bearings. The bearings given refer to the true meridian. The mean variation of the needle within each township has been calculated from the records given on the government plats. and thus the proper correction for each township has been obtained separately.

Rock numbers. The rocks collected constitute another numerical series. The rock numbers must not be confounded with those employed by my brother in former reports —especially the ninth, tenth and thirteenth. Undoubtedly many of my rocks are duplicates of his, but it must be left to the future to point out equivalences.

Rock identifications. The identifications and descriptions of rocks are less authentic than could be desired. They were made almost wholly in the field, often under circumstances which rendered impracticable close scrutiny even with a pocket handglass —still more in the absence of reagents, blowpipe, compound microscopes and books. These specimens, packed in the field, boxed and shipped at once to the headquarters of the survey, have not since been seen. Their re-examination and adequate study are neeessarily postponed.

Use of terms. In the use of terms the author deviates slightly from the German authorities most respected at the present time, and from a portion of the American authorities. Good reasons seem to exist for this, but it is not necessary to set them forth in the present connection. The divergence will result in no misconceptions if announcement is made in advance of the sense in which terms are employed. The following are not intended for *complete* definitions: By *granite* is meant a non-schistose aggregate of quartz, orthoclase and mica. When schistose, the rock is *gneiss.*

By *syenite* is meant a non-schistose aggregate of quartz, orthoclase and hornblende. When schistose, the rock is *syenite gneiss.*

An aggregate of quartz and orthoclase is *granulyte;* and this may be *gneissic* or *schistose.*

An aggregate of hornblende and orthoclase is *hyposyenite.*

An aggregate of hornblende and an acidic plagioclase is *dioryte.* This may also be *schistose.* It may also be *quartzose.*

An aggregate of augite and plagioclase, whether basic or acidic, is *diabase.*

Noryte is an aggregate of hornblende or augite with a basic plagioclase.

Gabbro is a form of noryte to which the pyroxene (augite) is lamellar (diallagic) and the plagioclase is a cleavable labradorite. The texture is mostly coarse.

I have endeavored to employ the once-outlawed term "graywacke," but there is much difficulty in fixing on a precise definition. According to Zirkel, "graywacke" forms a "clastic rock of most diverse grains. It is composed of angular or rounded grains of quartz, generally in predominating abundance, formed from fragments of siliceous schist or argillyte, with which are not unfrequently associated grains of feldspar, and in some varieties abundant mica scales, all cemented by a

binding material consisting of a clayey mass completely penetrated by silica, or even of silica alone. The siliceous clayey binding mass is often dark colored by finely divided particles of anthracite. The clastic elements mostly predominate over the binding mass, so that the latter is frequently difficult to distinguish. On account of the siliceous cement this rock posseses frequently, great toughness and hardness." In other words graywacke is essentially a fine, compact feldspathic sandstone with a silico-argillaceous groundmass.

Some use is made of the term *porodyte* introduced by Prof. M. E. Wadsworth (Bull. Mus. Comp. Zoöl. V, 280 and VII, 60). It is a rock having a greenish, compact, felsitic base, holding grains of quartz. In other words, it is a highly indurated feldspathic sandstone. It graduates into graywacke.

By *jaspilyte* I designate the siliceous, often jaspery, beds associated with iron ores. They are generally reddish, but often black, smoky, or colorless. The term is adopted from Wadsworth (Bull. Mus. Comp. Zoöl. VII, 76), but without any expression of opinion on the cause of the bedding.

The term *bed* and its correlatives is employed simply to denote a kind of structure. No implication is intended of the sedimentary or igneous origin of the bedding.

Principal lake regions. The geologic and physiographic data embraced in this report will be grouped about the following lakes: Vermilion lake, Mud creek and lake, Sand lake, Eagle Nest lakes, Burntside lake, Long lake, Fall lake, Garden lake, White Iron lake, Farm lake, Kawishiwi river, Basswood lake, Crooked lake, Iron lake, Newfound lake, Moose lake, Snowbank lake, Boot lake and vicinity, Ensign lake, Sucker lake, Knife lake, Ima lake, Thomas lake, Fraser lake, Kekekabic lake, Ogishke Muncie lake, Gabimichigama lake.

2.—VERMILION LAKE REGION.

The work of the season began upon the southeastern shores of this lake, but soon extended into the region lying eastward. The writer has little to say, therefore, of its geology. It is by far the largest lake in northeastern Minnesota, straggling over portions of townships 62 and 63 in ranges 15, 16, 17 and 18, west. Its coast line is extremely irregular and its surface is broken by scores of rocky islands. In recording my few observations I follow the order in which they were made.

HALT 1. S.W.¼, S. W¼, S. 20, T. 62-15. The rock here is hard and tough and of a gray color. It has been styled graywacke, and it certainly approaches the definition cited from Zirkel. It resembles Rocks 17,18 and 19 (Halts 9 and 10,) to which reference is made. It exhibits bedding planes dipping at a high angle—nearly vertical, and having a strike N. 82° W. Two sets of joints appear, one north 78° east and the other N. 48° E. In the midst of the graywacke formation appears a dike-like form, which, however, on close inspection, appears to be bedded in the direction of its length, and many of its laminæ reveal, on the weathered surface, an elaborately complicated system of plications. This dike-like form resembles, in composition, the country rock. The whole is intersected by a sinuous vein of quartz porphyry.

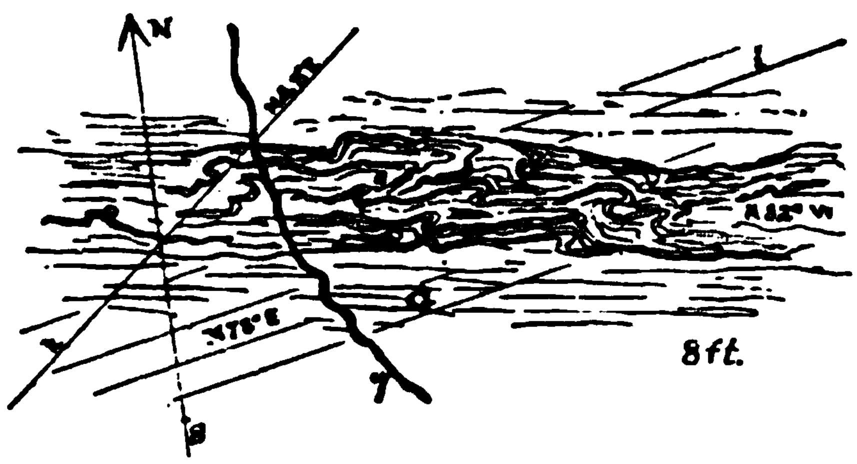

Fig. 1. Features observed at HALT 1, Vermilion L.
G, graywacke of the country rock.
g, dike-like bed of crumpled graywacke.
i, principal joints N 78° E.
k, second system of joints, N 48° E.
q, vein of quartz porphyry.

Rock 1. Graywacke from the country rock disposed parallel with the principal joints, N. 78° E. (See also Rock 71.)

Rock 2. Graywacke slate much plicated on weathered edge. Parallel with the bedding.

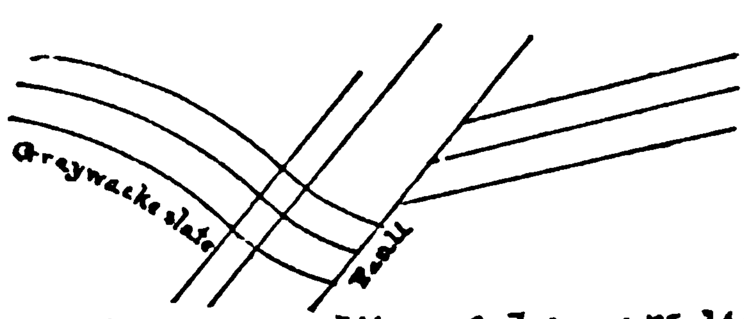

Fig. 2. Faulted condition of slate at Halt 2, Vermilion Lake.

HALT 2. Centre S. W. ¼, S.W.¼, S. 20, T. 62-15. Graywacke like that at Halt 1, but more slaty. Bedding strikes N. 84° W. Dip S. by W. 84°. Glacial striæ S. 8° W. A bed of porodyte-

like material 6 inches wide is included. The graywacke slate is faulted as shown below.

HALT 3. N. E. pt. S.W. ¼, S.E. ¼, S. 20, T. 62-15. Glaciated exposure of rock similar to last. Strike of bedding N. 85° W. Dip 88°. Glacial striæ S. 26° W. The country rock is slaty graywacke (rock 3) including a bed of porphyritically quartzose porodyte, which is elongated in the direction of the bedding, and itself inclosing irregular branching masses of quartz.

The beds of the country rock are rather various, ranging from graywacke slates, thick and thin, to argillyte.

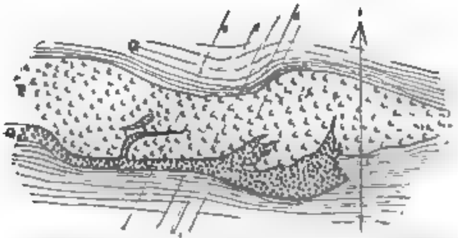

Fig. 3. Quartz included in porodite. Halt 3, Vermilion Lake.
a, graywacke slate. P, bed of porodite conformable with slate. Q, irregular masses of quartz in the porodite. t.t., glacial striæ S 26 W.

Rock 3. Graywacke slate, thick.
Rock 4. Graywacke slate, thin.
Rock 5. Argillitic graywacke slate.
Rock 6. Argillyte.
These are all beds of country rock.
Rock 7. Porphyritically quartzose porodyte.

HALT 4. About twenty rods N. E. of Halt 3 (inland) is another exposure of a very complicated kind. Distinct bedding planes with beds of same porphyritic material—beds of porphyritically quartzose sericitic schist, beds of coarse poroditic conglomerate, beds of conglomerated blue jasper and quartz—all in a state of great confusion and mutual displacement. In the sericite rock are rounded fragments of quartz-jasper, around which the leaves of sericite rock are partly wrapped.

At Halt 4 we find successions like this: Argillyte, argillitic sericitic schist, same with quartz grains, beds of poroditic porphyry, beds of poroditic conglomerate, rounded and ragged masses of jasper-quartz sometimes brecciated, sometimes with quartz and jasper interlaminated. All these seem to be contemporaneous, all parts of one formation.

The jasper-quartz appears to have been introduced in the form of foreign fragments. The sericite is wrapped around the knobs and bosses of it, and even fills narrow intervals standing vertically between contiguous masses of it. It appears plain that these fragments were dropped in when the sericitic mud was accumulating.

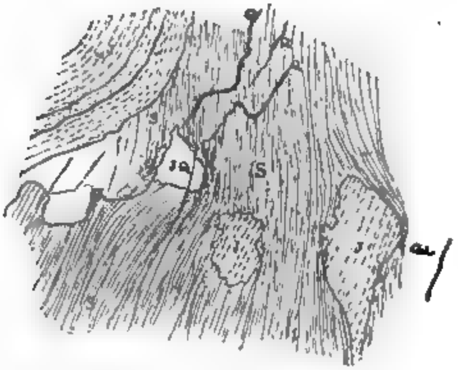

Fig. 4. Sericitic Schist and Inclosures, Nat ¼.
S, schist. J, jaspilite fragments. QQ, quartz veins.
Qu, quartz. JQ, jaspery quartz.

Some of these fragments are pure white quartz, and from them proceed veins of quartz across the bedding planes of the sericitoid. These quartzose, vein-generating masses may be subsequent.

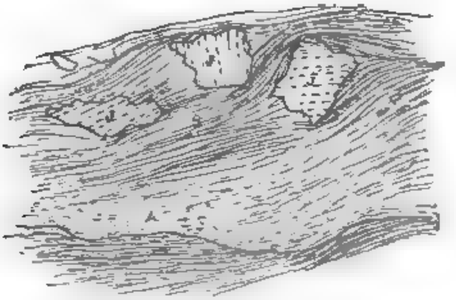

Fig. 5. Sericitic Schist and Inclosures, Nat ¼.
S, schist. J, jaspilite.

Figs. 4 and 5 show the fragments of jaspilyte with their own original bedding. Fig. 6 is a diagram of a jaspilyte breccia, like the other figures, made on the spot. The dotted material is an olive green sericite schist filling the interstices. The original

bedding of the fragments will be noticed here also. The lamination of the schist in Figs. 4 and 5 exhibits a bending and adaptation to the fragments of the jaspilyte. Evidently the fragments were introduced while the layers of schist were forming. The fragments of jaspilyte, as shown in all the figures, were broken from some pre-existing formation, where they had already received their banded structure. They had not been far transported, for their edges and angles are yet sharp. At A in Fig. 5 is a region where the schist graduates into quartz. From this it appears that some quartz was forming contemporaneously with the schist. At JQ Fig. 4, is a fragment of jaspery quartz showing that something jaspery has characters also similar to the contemporaneous quartz. The brecciated regions at this locality are ill-defined varying bands running with the bedding of the schist for limited distances. On each side of the portions figured, the formation is substantially a sericitic schist.

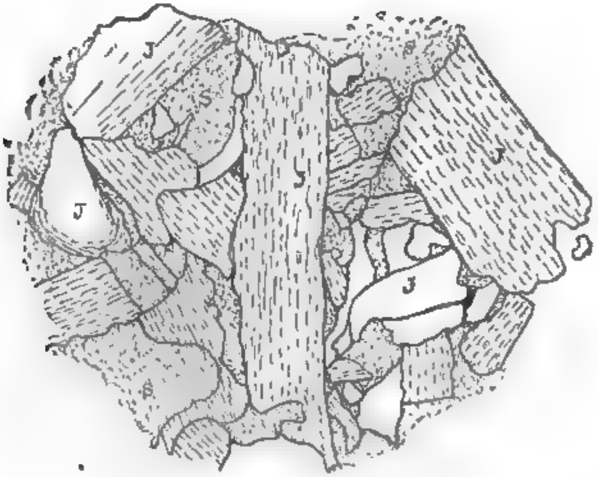

Fig. 6. Relations of Jaspilite and Sericite Schist HALT 4.
J, jaspilite, with broken lines. S. schist, stippled.

HALT 5. S. W. ¼, S. W. ¼, Sec. 21, T. 62-15. Strike N. 60° E.

Rock 8. Sericitic schist.

Rock 9. Sericite schist with quartz grains.

Rock 10. Quartz veins in graywacke schist.

HALT 6. Stuntz' I. N. W. ¼, S. W. ¼, Sec. 21, T. 62-15. The mass of the rock is poroditic conglomerate. Bedding planes

N. 56° E. Beds somewhat sericitic, some layers largely so — others conglomeritic. Included are also plates of black jasper conformable with the bedding.

Crossing the bedding are two sets of dikes — one N. 76° E; the other N. 74° E. dip of beds, S. 82°.

Rock 11. Older system of dikes (so-called).

Rock 12. Later system of dikes (so-called). Sericitic schist with thin white scales of talc (?)

HALT 7. 20 rods north of Halt 6.

Locality of porodyte. Beds strike N. 66° E. Dip 75°.

Rock 13. Porodyte (so-called).

This rock is a massive subgranular felsyte. Texture not granular, but still not uniform. Besides this, delicate interrupted, irregular films of darker matter run in rudely parallel planes through the mass. General color of rock light, with a pale waxy tinge pervading it, weathering nearly white. On the weathered surface of the exposure are wavy, irregular grooves, or seams, which I regard as bedding lines, having the strike indicated above.

From observations made in this vicinity it appears that all these rocks belong to one formation, in a large sense. They are all — graywacke not excepted — pervaded by a magnesian element. In the porodyte we find serpentine masses one, two or more inches long, of a pale greenish color and lamellar structure.

HALT 8. S. W. ¼, S. E. ¼, Sec. 34, T. 62-16. Poroditic felsyte; some parts with grains of quartz. Strike N. 67° E. Dip 82° N.

Rock 14. Poroditic felsyte.

Rock 15. Porphyritically quartzose porodyte, like Rock 13, only few quartz grains.

Rock 16. The so-called quartzyte.

Rock 17. Very dark, schistose, augitic, with feldspar (?) and quartz grains resembling chrysolite, except in color.

The foregoing rocks occur in different beds of this formation.

HALT 9, N. E. ¼, N. W. ¼, Sec. 3, T. 61-16.

Rock 18. Apparently a compact graywacke.

The rock at Halt 9 is compact, very indistinctly bedded, grayish, composed of waxy feldspar and a dark mineral which looks like augite. There are also scattered, glassy grains which have the cleavage, structure and hardness of a plagioclase. This rock, however, is very nearly identical with Rock 1, which is distinctly bedded.

HALT 10. N. E. ¼, N. E. ¼, Sec. 3, T. 61-16. Rock dark, distinctly slaty, lustrous, permeated by a glassy feldspar, which apparently causes the lustre, but occurring also in crystals. Strike N. 79° W. Dip 82°. Glacial striæ S. 23° W.

Rock 19. Graywacke.

The rock at Halt 10 is different from any yet seen. It looks much like a hornblende schist, but there is evidently a large percentage of fine, grayish, feldspathic particles. In fact, I suspect the whole dark constituent is a feldspar (labradorite). There are also disseminated grains like garnets or staurotide, giving the bedding surfaces a pimpled appearance.

Rocks 17 and 18 are embraced in what is provisionally termed graywacke. They are very similar to Rock 1. Rock 3 is similar to these but pervaded by more of a greenish, serpentinoid constituent. Rock 4 resembles Rock 1, but is thin bedded. Rock 18 is little distinguishable from 1.

On the iron mines in this vicinity but few observations were made, and those mostly for comparative purposes.

HALT 63. Stone iron mine. N. W. ¼, S. E. ¼, S. 27, T. 62-15. A ridge of generally schistose character. Beds trending nearly east and west, and standing almost vertical. Consist, before we reach the summit from the north, of banded jaspery iron schists. At the summit they are essentially sericitic, becoming in places a little chloritic, and in others, a little argillitic. The iron ore deposit occupies about 50 feet and has been excavated to depths of 50 to 80 feet. The schists have a dip northward

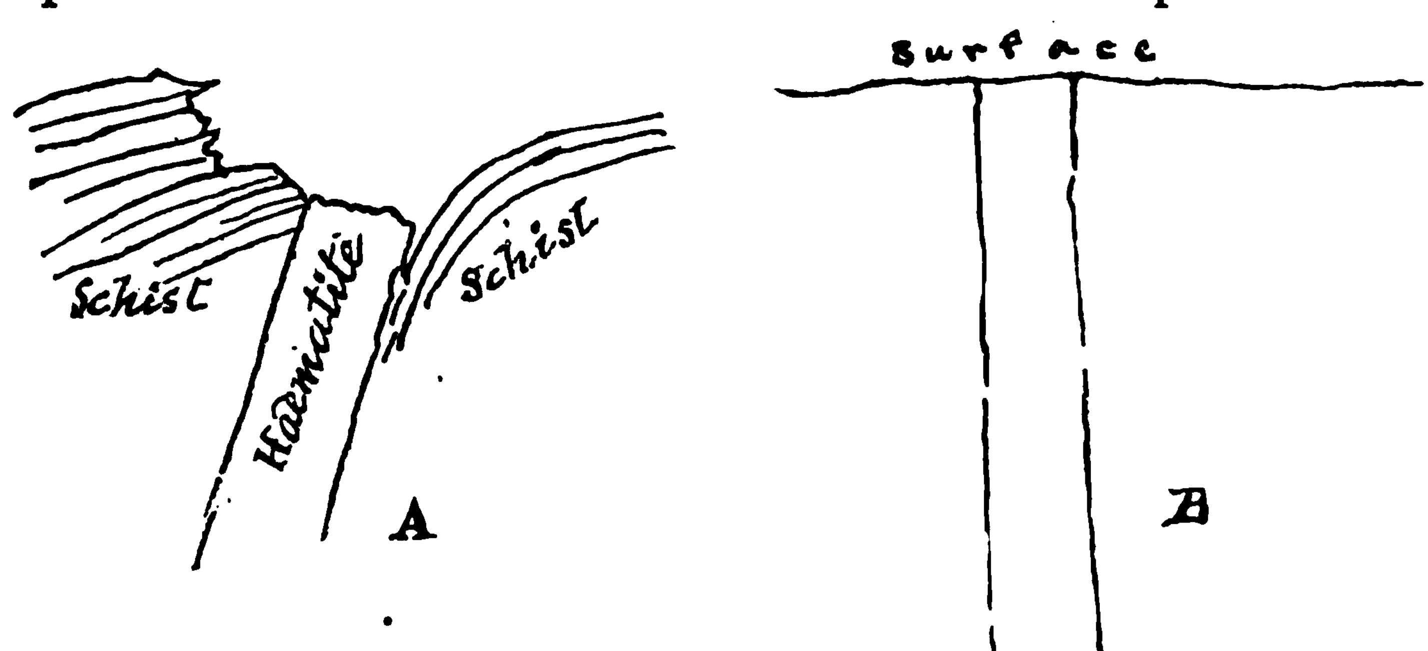

Fig. 7. Views of so-called Dike at Stone Iron Mine
A, Plan on the surface. B. Vertical section in south face of mine.

of about 82°. The south or foot wall is more chloritic and argillitic. The beds are bent, interrupted, crumpled, knotted, smooth-faced.

The structural state of the ore is difficult to ascertain. I judge it from appearances to have bedded arrangement comformable with the schists, but the bedding is certainly less distinct. Some of it is apparently massive. On the south side is an abrupt ledge which has been worked out four or five rods. There are indications here of bedding conformable with that of the formation, but it is not easy to be certain.

In one place, on the south face of the mine, is a southward protrusion of the ore into the schists for a certain distance—how far is not known. This has been pronounced a dike. On the east the schists are bent around toward parallelism with the iron-intrusion. On the other side they are not. On neither side is there anything like a definite wall. The ore and shale and earth blend and intermingle in a way similar to that shown between the main ore and the country rock.

HALT 64. Ely mine, a few rods west of last. An excavation 25 feet deep, and in one part 65 feet. The east side of the deep excavation shows the iron lode divided into three or more parts, like this:

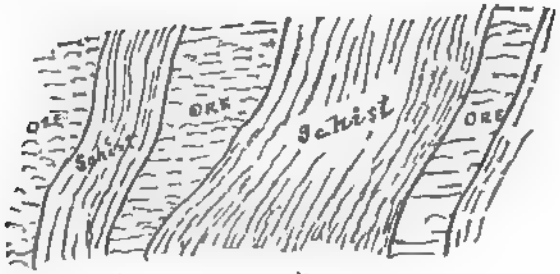

Fig. 8. Dikes so-called in Ely Iron Mine, Town.

These divisions of the lode, I understand, have been regarded as dikes.

The following diagram shows a nearer view of one of the dikes. It appears still further divided by beds of ferruginous schist, *a'*, *a'*.

Fig. 9. A nearer view of one of the so-called "dikes." a a a' a', Ferruginous schist (Red Chalk). a' a' Still further divisions of the "dikes."

HALT 65. Railroad cut south of Ely mine. This runs along the strike of the sericitic schists; but it exhibits somewhat the nature of the transition from the iron deposits to the schists. In places, that transition is abrupt, and this is seen in the Stone mine; but here we find places where the transition is gradual, either alternating thin layers of jasper and sericite with diminishing amount of jasper, or dissemination of grains of quartz in diminishing abundance through the sericite. These phenomena are not compatible with the doctrine of the dike-like nature of the iron deposit.

HALT 66. Part way down the mountain, on the trail to Stuntz bay. Some magnificent examples of red and black banded jaspery hæmatite. Some of the hæmatite bands are superior ore. Many of them are wonderfully plicated.

HALT 11. S.W. ¼, S.W. ¼, S. 6, T. 62-14. North side of Mud Creek bay, very near the town line. Ridge close by the bay, about 80 feet high, consists of so-called graywacke with many layers slaty, more and less. General hue greenish; sound portion fine grained. Strike E and W. Dip 75°. Quartz veins mostly conformable with bedding.

Rock 20. (From one of thicker beds.) Fine, almost aphanitic, greenish-gray, homogeneous, tough. It is a felsitic schist. Some beds are greenish with a real slaty structure, and might be designated a chloritic slate.

3.—MUD CREEK AND LAKE.

Entering Mud creek from Vermilion lake, we find a stream about six feet deep and less. The water is clear, but filled with *Nuphar lutea* (with another species) and exquisite *Nymphæa odorata*. In N.W. ¼, N. E. ¼, S. 8, a portage of a third of a mile occurs. It is wet and difficult.

HALT 12. N. E. ¼, S. E. ¼, S. 5, T. 62–14. Bench of hill north of Mud creek, opposite east end of portage. Strike N. 60° E., bending to N. 40° E. Dip S. 87°. Chloritic slate, passing into argillyte very thin and slaty. Interbedded with porodyte, porphyritic with feldspar and quartz.

Rock 21. Chloritic sericitic schist.

HALT 13. First foot hill a few rods north of Halt 12, 54 feet above Mud creek. Thinly laminated sericitic schist. Dip 90°.

Rock 22. Sericitic schist—rusty blotches—feldspathic grains.

HALT 14. N. E. ¼, S. E. ¼, S. 5, T. 62-14. Top of hill 200 feet. Strike of beds N. 57° E. Chloritic slates, very irregular in structure — thick and thin-bedded — some graywacke-like in aspect.

Rock 23. Graywacke.

Here are some fragments of jaspery hæmatite. Close by on the north is a solid greenish rock.

HALT 15. Hill 20 rods north of Halt 14. Rock poroditic, with beds of chloritic slate, but mostly with very obscure bedding. Strike N. 50° E. Dip S. 88°. Schistosity N. 30° E.

HALT 16. S. W. ¼, N. W. ¼, S. 3, T. 62–14. At eastern extremity of Little Mud lake. At base of hill. Rock poroditic. A considerable greenish material. Some beds pretty compact, with disseminated grains of quartz, and also grains of pale greenish feldspar — a sort of quartz-porphyry. Other beds a little slaty, with sericitic surfaces. Strike N. 57° E. Dip S. 70°.

Here, twenty years ago, says Charley, our Indian, some adventurers blasted an excavation in the hill-side. I see nothing to allure them except a little yellow pyrites.

Rock 24. Quartzose porphyry.

HALT 17. S. E. ¼, N. W. ¼, S. 3, T. 62-14. South side of Mud lake. Hill rises just back of shore, 80 feet high. A rounded range of quartz porphyry, not essentially different from what has been seen so frequently. Some of the quartz grains are half an inch and over in diameter. I notice here, more than before, their tendency to quadrangular sections. The bedding planes can hardly be detected. The rock is profoundly shattered by joints. It is impossible to get normal specimens. It weathers whitish gray and is very rough. Strike (what seems most like it) N. 79° E. Dip of bedding 78° S. Many of the joints coincide with the bedding; others run N. 42° E. and dip N. 72°.

Rock 25. Quartz porphyry.

Rock 26. Bluish, fine, compact felsite.

Some of the beds of this formation approach a slaty character. There are beds with the same plicated internal structure as seen at Halt 1. Immediately contiguous are hard, bluish, nearly homogeneous beds, breaking in many directions, and resembling a fine trap-like anamesyte.

Rock 27. Anamesyte-like (not anamesyte).

HALT 18. N. W. ¼, N. E. ¼, S. 3, T. 62-15 — or a little over the line in T. 63. Rock similar to Rock 27. Very rugged, dark, yet

in places it appears thin-bedded, and approaches the character of an argillitic, chloritic schist of bluish-green tint.

Rock 28. Anamesyte-looking, like Rock 27.

Rock 29. Chloritic schist, very irregular.

Notwithstanding the bedded spots, I can not find any general trend to the beds. They are short, cuneiform and confused. The rock is similar to the last mentioned, quite at the water's edge.

HALT 19. S. E. ¼, N. E. ¼, S. 3, T. 62-14. Point north side of Mud lake. Rock exactly like that at Halt 17. Strike N. 59° E. to N. 68° E. Dip 90°.

Rock 30. Quartz porphyry, same as Rock 25.

HALT 20. S. E. ¼, S. W. ¼, S. 2, T. 62-14. On portage south of east end of Mud lake. Two ranges of hills about 125 feet high. Rock greenish, chloritic, like that at Halt 19, near the water.

HALT 21. N. W. ¼, S. 12, T. 62-14. On the portage. Slight outcrop.

Rock 31. Compact graywacke.

This portage, so-called, passes over numerous ranges of hills, and is nothing more than a trail. The rocks seen in the hills are greenish, compact and graywacke-like.

4.—SAND LAKE AND VICINITY.

The portage does not touch the little lake between sections 2 and 11. It exceeds two miles in length and winds much. It terminates on a little lake having an island in the centre. This, according to Charley, is lake A-ba-kwa, or Cat-tail lake. There are no outcrops around this island. On the west side is a portage of a third of a mile, which is dry and cut out as if for a wagon road. The lake at its western termination is Nameless. The shores of this lake are without rock exposures. At the southeast angle is a very good portage of about a third of a mile. This takes us to Sand lake, or, as Charley calls it, Mi-da-ung Sa-ka-i-kan.

HALT 23. S. E. ¼, N. W. ¼, S. 13, T. 62–14. Between Nameless and Sand lakes. No distinct outcrops, but many large pieces of jaspery hæmatite and compact gray-wacke.

Rock 32. Jaspery hæmatite.

HALT 24. S. E. ¼, N. W. ¼, S. 13, T. 62–14. East end of Sand lake. Fine sandy beach without rocky outcrops. A few loose bowlders line the shore westward, and a range of hills, 200 feet high, stands a third of a mile back.

HALT 25. N. E. ¼, S. W. ¼, S 14, T. 62–14. Northwest part of Sand lake. Outcrop of a compact, graywacke rock, near the shore—very hard and tough, and full of joints, but much like rocks heretofore seen, at Halt 21 especially. In some of the joints are surface crystallizations of hæmatite. Some portions show obscure mottlings. The weathered aspect of the rock is much like that of a greenstone.

Rock 33. Graywacke. Some portions approaching chloritic schist, but this is the same as heretofore seen.

HALT 26. N. W. ¼, S. W. ¼, S. 14, T. 62–14. A ledge of graywacke rock essentially like last, but with veins of a reddish mineral resembling heulandite, and some disseminated specks. I notice a vein of heulandite (?) a quarter of an inch wide, having a green vein of epidote in the center. The rock contains a good deal of chlorite, and in some joints this becomes conspicuous.

Rock 34. Chloritic, massive graywacke, with veins of heulandite (?) and chlorite.

About eight rods further inland the formation is essentially the same, but contains bands of a mineral having a metallic lustre and looking like jaspery hæmatite, but it gives no red streak—nor black one. In fact, it is as hard as quartz, but too lustrous for a mere jaspery mixture. Contains jasper bands.

Rock 35. Graywacke, compact and massive, with metalliferous bands.

We passed into Armstrong river with a view of reaching Armstrong bay. Soon found fallen trees obstructing the passage. Some of these we cut out, but we soon learned that the stream is not canoeable.

HALT 27. Armstrong River rapids, about one-half mile from the entrance. Here is a disturbed outcrop of black jaspilyte interbedded with greenish chloritic schist. Strike N. 82° W. Dip N. 82°.

Rock 36. Black jasper schist.

Rock 37. Dark chloritic schist, interbedded with the last.

I find in this jasper schist thin bands of the metallic substance seen at Halt 26.

A quarter of a mile further west occur other rapids and narrows. As no distinct trail could be found in the vicinity, it is evident no thoroughfare exists between Sand lake and Armstrong bay. At the southwest angle of Sand lake is a portage.

HALT 28. W. side N. W. ¼, S. 23, T. 62–14. Half way on portage to Eagle Nest lakes. Outcrop of graywacke.

5.—EAGLE NEST LAKES.

These are two very irregular lakes lying in the south eastern part of T. 62–14. Their general trend is northeast and southwest, and they approach within a quarter of a mile of each other. Around the shores of the northern lake is much low ground, but on the southern lake are numerous rocky exposures.

HALT 29. S. W. ¼, N. E. ¼, S. 22, T. 62–14. Northern extremity of North Eagle Nest lake. Outcrop of jasper schists

HALT 30. S. E. ¼, N. E. ¼, S. 22, T. 62–14. Outcrop of epidotic graywacke mixed with heulandite (?).

Rock 38. Epidotic graywacke with heulandite (?).

HALT 31. N. E. ¼, N. W. ¼, S. 22, T. 62–14. Rock schistose, some parts highly ferruginous.

Rock 39. Ferruginous graywacke. Needle was affected here —turned eastward.

HALT 32. N. E. ¼, N. W. ¼, S. 33, T. 62–14. No outcrops of rock in this vicinity. A few bowlders.

HALT 50. S. W. ¼, N. W. ¼, S. 27, T. 62–14. At isthmus of the peninsula on northwest side of North Eagle Nest lake. Formation graywacke, obscurely bedded, greenish in places with epidote—some epidote veins—some dough-like masses with fibrous bedding in section. Innumerable felsitic veins and disseminated grains, and when the latter weather out, the aspect is amygdaloidal.

Rock 54. Epidotic graywacke schist.

Rock 55. Epidote crystallizing.

I find some calcite imbedded in the rock.

HALT 33. N. E. ¼, S. E. ¼, S. 24, T. 62–14. Small island in South Eagle Nest lake. Sericitic schist with bedded structure distinct. Not so soft as some seen—more compact. Strike N. 70° E. Dip N. 82°. Some beds reddish with red fedspar which, in places, forms the principal mass, and amounts to a felsitic schist.

Rock 39 *bis*. Sericitic schist more compact.

Rock 40. Chloritic sericitic schist.

HALT 34. N. E. ¼, S. E. ¼, S. 26, T. 62–14. Main land opposite Halt 33, north. Rock a compact thick-bedded, sericitic, much-jointed formation. Strike N. 71° W., but obscure and uncertain. Joints N. 8° E.

Rock 41. Compact chloritic sericitic schist.

HALT 35. N. W. ¼, S. W. ¼, S. 25, T. 62–14. Chloritic

schist, dark, soft, distinctly bedded. Strike N. 75° W.—second place N. 84° W. Dip N. 75°.

Rock 42. Chloritic sericitic schist.

Most of this exposure is not especially chloritic. Veins of reddish felsyte exist.

HALT 36. N. E. ¼, N. W. ¼, S. 36, T. 62-14. Main land. Cliff 50 feet high. Chloritic sericitic schist.

HALT 37. N. E. ¼, N. W. ¼, S. 36, T. 62-14. Main land. Cliff 50 feet. Dip N. 80°. Graywacke sericitic schist.

HALT 38. N. W. ¼, N. W. ¼, S. 36, T. 64-14. On large island. Cliff 50 feet. Chloritic graywacke schist, some portions quite fine, compact and hard. Distinctly bedded.

HALT 39. S. W. ¼, N. W. ¼, S. 36, T. 62-14. Rock islet 40 feet long and 20 feet broad, consisting of jaspery schist, dark, banded, hæmatitic. May not be in place.

The needle here is much disturbed. As nearly as I can judge by the sun, the strike of these bands is N. 18° E.

Rock 43. Jaspery ferruginous, sericitic schist.

HALT 40. N. W. ¼, N. W. ¼, S. 36, T. 62-14. Small island. Rock mostly sericitic schist, but with minute, micaceous glistening scales.

Rock 44. Sericitic or damourite schist.

HALT 41. N. W. ¼, N. E. ¼, S. 35, T. 62-14. West point of small island. Graywacke schist.

HALT 42. S. W. ¼, N. E. ¼, S. 35, T. 62-14. Main land. Chloritic sericitic schist.

HALT 43. S. E. ¼, N. W. ¼, S. 35, T. 62-14. Main land. Sericitic schist. Bedding rather distinct. Strike N. 82° E.

HALT 44. S. E. ¼, N. E. ¼, S. 34, T. 62-14. Little island not on plat. Sericitic chloritic schist.

HALT 45. N. E. ¼, S. E. ¼, S. 34, T. 62-14. Main land. Chloritic, sericitic schist.

HALT 46. S. W. ¼, N. E. ¼, S. 34, T. 62-14. Islet not on map. Chloritic sericitic outcrop, with quartz disseminated and in veins. Also some disseminated feldspar and felsitic bands.

Rock 45. Chloritic sericitic schist, with quartz and feldspar.

HALT 47. S. W. ¼, N. E. ¼, S. 34, T. 62-14. Point of main land. Strike N. 89° E. Dip 75° N. Rock still essentially chloritic-sericitic, with parts inclining to graywacke. Intersected by small quartz veins and by veins of felsyte—some felsyte veins having quartz veins along the middle.

Much of the rock is soft, greenish and chloritic. The weath-

ered surfaces are rough, with projecting quartz grains. In places the quartz veins are like threads, forming a net-work. These veins have no determinate direction.

Portions of the rock are a greenish felsyte, but these are neither in beds nor veins. They are very fine and aphanitic. Some of the felsyte portions are porphyritic with feldspar.

It contains amorphous masses of quartz, 10 inches by 15, including smaller masses of feldspar.

Rock 46. Sericitic schist, soft portion.

Rock 47. Petrosilex and felsyte bedded.

HALT 48, N. E. ¼, N. W. ¼, S. 34, T. 62-14. Point of main land marked "Quartz" on plat. Strike N. 83° E. Dip about 75° N.

Outcrop in all respects similar to last, but with the quartzose and felsitic features somewhat stronger, a large part of the rock inclining to be compact and hard.

Rock 48. Sericitic schist, granular, compact.

HALT 49. N. E. ¼, N. E. ¼, S. 34, T. 62-14. Angle of main land. Mining oporations have been carried on here. An eighth of a mile back from here a shaft has been sunk, apparently twenty-five feet at least.

Rock 49. Quartzitic sericitic schist, thick bedded and rusty.

Rock 50. Chloritic, sericitic schist with pyrites.

Rock 51. Sericitic schist thin-laminated.

Rock 52. Quartz vein, ferruginous.

Rock 53. Pyrites in quartz.

The outcrop is not essentially different from many others. The formation is fundamentally sericitic, and planes of bedding can be seen as at other places, but the first rock on the surface is a rusty magnesian rock containing grains mostly blended with the matrix, but reminding one of the poroditic rock, so-called, on Vermillion lake. Some specimens even contain the quartz-like mineral, so much resembling andalusite in form. The weathered surfaces are quite friable, but the sound rock is seen permeated by a red mineral. This is Rock 49. This formation is irregularly intersected by quartzose and feldspathic veins like that at Halt 47. The abandoned shaft is about six to eight feet in diameter, with many tons of rock thrown out. Here we find the most abundant fragments are a chloritic, sericitic schist—Rock 50—containing, frequently, cubes and masses of pyrites disseminated through it. Other portions of the formation are a fine, laminated, translucent, sericite schist, which is intersected by veins of quartz and iron pyrites. This is Rock 51.

Many quartz veins run through the whole formation. Rock 52 is a sample, containing hæmatitic stains, very much indeed as in some argentiferous quartz. Other quartz veins are pervaded by pyrites in abundance, as shown in Rock 53. In some cases a mass half the size of one's head is pure pyrites. The pyrites and quartz are sometimes seen to be intersected by minute, sinuous veins of a dark, lustrous, iridescent mineral resembling "peacock ore" of copper. These are the glittering minerals which sustained, not without some reason, the hopes of the adventurers.

HALT 51. N. W. ¼, S. W. ¼, S. 13, T. 62-14. On the portage from N. Eagle Nest lake west. Felsitic graywacke, epidotic like that at Halt 50. Strike N. 68° W. Glacial striæ 20° S. W.

HALT 52. S. E. cor. N. E. ¼, S. 29, T. 62-14. On the portage. Epidotic graywacke, weathering sericitic in aspect. Strike east and west.

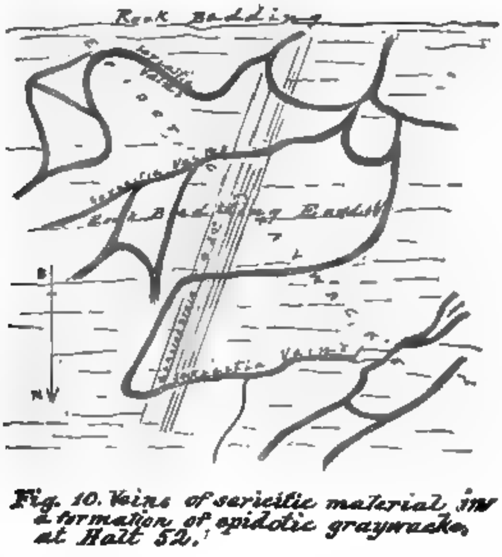

Fig. 10. Veins of sericitic material in a formation of epidotic graywacke, at Halt 52.

This smooth-topped exposure is curiously marked by veins of a sericitic material similar to portions—especially weathered portions—of the country rock. The formation is seen stretching along to the north of the east point of the little lake in section 29.

HALT 53. N. E. ¼, S. E. ¼, S. 29, T. 62-14. East end of little lake—Gem lake. Graywacke, more chloritic than epidotic.

HALT 54. S. W. ¼, N. E. ¼, S. 29, T. 62-14. North side of Gem lake. General aspect of rock slaty-blue and distinctly bedded. It might be called compact chloritic slate; but it retains a graywacke aspect, showing that the formation is fundamentally the same. Here, also, is a set of reticulating sericitic veins, like those at Halt 52—but these are slaty blue. *The bedding lines continue their course across these veins.* This indicates that the bedding lines are superinduced in the formation, and not sedimentary planes. Strike N. 89° E. Joints N. 30° E. Same rock continues west to near portage.

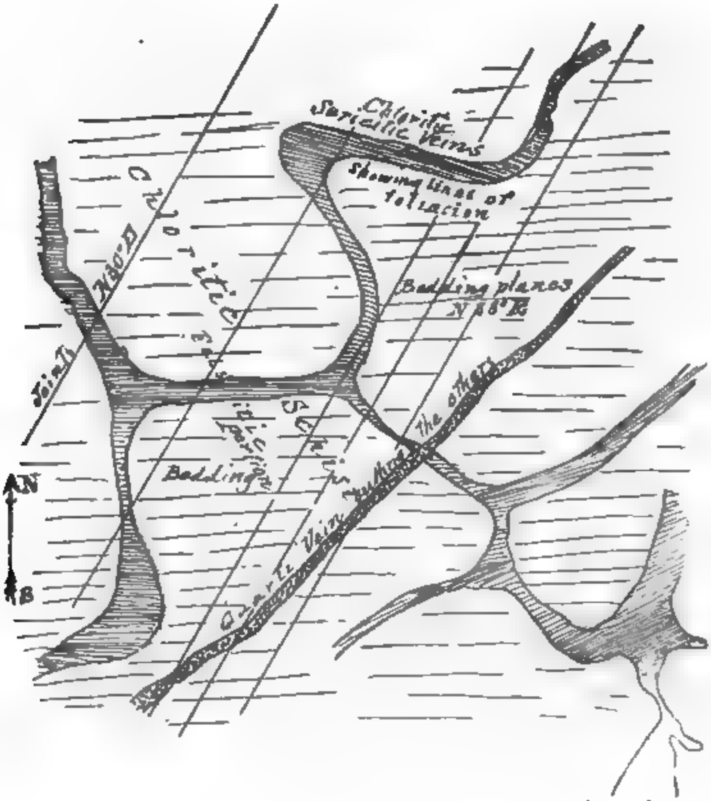

Fig. 11. Reticulating Veins of Sericitic material at Halt 54.
Horizontal Surface.

HALT 55. S. E. ¼, N. W. ¼, S. 29, T. 62-14. S. W. side of Gem lake. Rock exactly like that at Halt 54.

Rock 56. Chloritic schist, heavy-bedded.

Rock 57. Chloritic schist forming a vein.

Strike of beds E. and W. *Lines of structure in the veins here incline to run parallel with the walls of the veins.*

HALT 56. Centre of N. W. ¼, S. 29, T. 62-14. On little lake at portage northwest—Gem Lake. Outcrop exactly like Halts 54 and 55. These chloritic schists are not characteristic schists, but approach metamorphic conditions, having a striking external resemblance to diabasic rocks. They are cut up with joints, and the bedding is very irregular.

The structure of the veins follows their direction.

A blind trail leads from here to Saddlebags lake—the next little lake to the northwest.

HALT 57. N. W. ¼, N. W. ¼, S. 29, T. 62-14. S. E. side of Saddlebags lake. Only a few drift bowlders are seen here.

HALT 58. S. W. cor. S. 20, T. 62-14. E. side of Saddlebags lake. Outcrop of chloritic graywacke.

HALT 59. N. W. ¼, S. W. ¼, S. 20, T. 62-14. N. E. point of lake. Graywacke, barely outcropping. A few rods back, the rock approaches a gabbro.

HALT 60. N. ½, S. E. ¼, S. 19, T. 62-14. N. E. shore of the lake. No outcrop, but we find a bark shelter recently occupied. Ascended a hill to the north, but found no outcrop. Turned south around the swampy point but found nothing. At the shelter picked up a fragment appearing to contain lamellar labradorite—in fact consisting chiefly of it, but it is rather soft.

Rock 58. Labradorite (?) chiefly.

Found also some loose fragments of banded hæmatitic jasper, too hard to give a streak.

Rock 59. Ferruginous jasper, as above.

HALT 61. N. W. ¼, S. W. ¼, S. 19, T. 62-14. Commencement of portage to Armstrong bay—16 rods. Graywacke schist, vertical—8 rods farther, iron jasper schist—16 rods farther, ferruginous slate—16 rods beyond, banded iron jasper schist, elevation about 200 feet—20 rods farther, a valley—20 rods beyond, jasper on a hill about two hundred feet high, 16 rods still farther, jasper iron schist. Needle much disturbed. Thirty rods beyond, red and black iron schist—16 rods, chloritic graywacke schist. Here is a little cool creek running west.

HALT 62. N. W. ¼, N. E. ¼, S. 19, T. 62-14. Hill on portage, 200 feet high. Large outcrop of quartz porphyry.

Rock 60. Quartz porphyry.

This is succeeded abruptly, on the north, by jasper schists

dipping N. 82°, 20 rods—followed by porphyry again, 20 rods. Then jasper schist, brecciated and quartzose, with a matrix of quartzose porphyry, twenty rods, then a feeble exposure of mottled felsyte, 30 rods, then, finally, quartzose porphyry. Nothing more outcrops for 50 rods, to the end of the portage. The distances, of course, are simply estimated.

We may now write in order, the rocks observed southward from Armstrong's bay:

No rock observed in place	16	rods
Quartzose porphyry	25	"
Mottled felsyte—small exposure	30	"
Jasper schist, brecciated and quartzose	24	"
Quartz porphyry (200 feet)	25	"
Jasper schist, dipping N. 82° E	25	"
Quartz porphyry	12	"
Valley and little stream	12	"
	—169	"
Chloritic graywacke schist	16	"
Red and black jasper iron schists	30	"
Jasper iron schist. Needle disturbed	16	"
Iron jasper (200 feet)	20	"
Valley	20	"
Banded iron jasper schist (200 feet)	16	"
Iron slates	16	"
Iron jasper	8	"
Graywacke schist, vertical	16	"
Total, 5,300 feet	327	rods

The whole section of 5,200 feet, in a straight line, is divisible into a quartzose porphyry series of about 2,700 feet and a jaspery series of 2,600 feet.

6. BURNTSIDE LAKE.

This noble and beautiful lake, called by the Indians Ga-na-ba-ne-ia-bi-gi-teia-ga-mak, stretches diagonally across township 63-13. It extends about a mile into range 14, and a mile and a half into range 12. A northern arm not less than three miles long, reaches into township 64; but neither this township nor the one on the west has yet been surveyed, and the locations of halts within them are yet conjectural. Into a northern arm of the lake empties a deep, clear and boatable stream, which issues from three small lakes, the largest of which, Pretty lake, is over a mile long, and extends into township 64. The whole length of

Burntside lake is about eight and one-half miles, and its mean breadth about one and one-half miles. Its shores are mostly rocky and elevated, but not inaccessible. Hundreds of rocky islands diversify its surface and constitute quite a labyrinth. The original forest has mostly disappeared by burning, though Norway pine of fair quality occurs in patches along the south shore; and white and Norway pines of fine growth occur upon the shores of the little lakes and the deep bay upon the northern border. The thin soil is in possession of great quantities of blueberry and raspberry bushes, which, in their season, furnish a grateful supply of food, while at all times, the scarlet wintergreen berries supply a garnish to the dun aspect of the surface. The lake abounds in excellent pickerel and pike, and it is said the white fish, as in Vermilion lake, is sometimes caught. Some day, the pleasure-seeker will discover the charms of Burntside lake to exceed those even of the "Thousand Islands" in the St. Lawrence.

Opportunities for geological study are unsurpassed. The primitive mossy covering has been removed from the rocky exposures by fire, and whole acres of rocky beds lie with their upturned edges ready for the geologist to trace their succession across thousands of feet, and note the methods of transition from formation to formation. Here in fact, is the most instructive geology in the Northwest. Careful studies were made upon all sides of the lake and on scores of the islands.

Only the western portion of the north shore of the lake remains unstudied.

The route proceeds from the eastern extremity of Mud lake over the usual portage and thence along the western and southern shores to the eastern extremity, excursions being made to several of the islands on the way. From the eastern extremity the route returns over the north shore and the contiguous islands on the one hand, and lakes on the other to section 16, where the survey was interrupted.

HALT 68. About one-fourth mile on portage. Outcrop of graywacke.

The portage embraces a broad, wet swamp; but half the portage is dry. The swamp lies between two ranges of hills.

HALT 69. Sec. 25 (supposed) T. 63-14. Near end of portage, on creek flowing into Burnside lake. Outcrop of micaceous schists. Strike N. 59° E. Dip N. 60°. These schists consist apparently of biotite, muscovite and quartz. The mica scales are

fine. The muscovite is light gray and looks sericitic, but the scales are bright. The formation is intersected by veins of biotite granite belonging to two systems, as shown below.

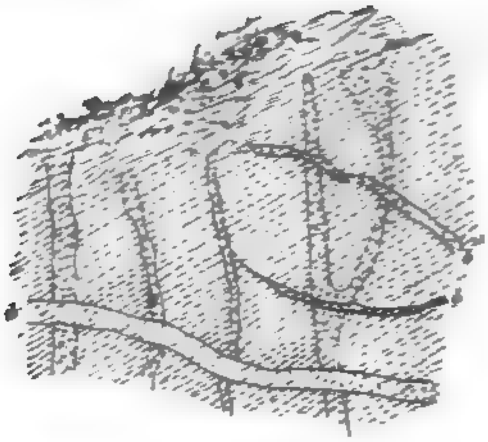

Fig. 12 Granite Veins in muscovite-biotite schist at Halt 69, near Burntside Lake. Vertical Face of cliff. a & b Granite with little mica.

From this point a fine and navigable creek, six feet deep and and twenty-five feet wide, flows into Burnside lake.

HALT 70. S. 25? T. 63-14. On creek three-fourths mile beyond portage. Mica schist exactly like that at Halt 69. It rises in a high, broken front with granite veins as in the other locality.

HALT 71. Sec. 36? T. 63-14. About 1½ miles beyond the portage. A wall of massive mica schist comes down to the water, having two sets of granite veins as at Halt 69.

Rock, 61. Compact graywacke mica schist.

Rock 62. Granite vein.

HALT 72. One-fourth mile from Burntside lake. North side of creek. Graywacke mica schist, with a net work of granulyte veins.

HALT 73. On the opposite side, at the entrance to the lake, a bold promontory of mica schist intersected by granitic veins. Similar bold bluffs continue along the west end of the lake. Dip N. 60°.

At one place is a granitic intrusion about forty feet wide. Consists of rather fine-grained, reddish feldspar and quartz, with many large grains of free quartz.

Further along (west end) the mica schist is very fine and compact, and still contains veins of granite. Same continues to N. W. corner of lake.

HALT 74. South shore, near the S. W. corner of the lake. Very fine and compact micaceous rock.

HALT 75. N. W. ¼, S. W. ¼, S. 32, T. 63-13. Base of point south shore of Burntside lake. Very fine grained mica schist, bluish and hard, and having granitic veins.

Rock 63. Graywacke mica schist.

Rock 64. Very fine compact mica schist.

HALT 77. S. W. ¼, N. W. ¼, S. 32, T. 63-13. On the point. Mica schist. Strike N. 58° E.

Rock 65. Mica schist.

HALT 78. Near centre of section 32, T. 63-13. Well marked mica schist distinctly laminated and fine-grained. Dip S. 60°.

Rock 66. Mica schist.

HALT 79. N. W. ¼, N. E. ¼, S. 32, T. 63-13. At extremity of point. Mica schist with granitic dikes. Strike N. 71° E. to N. 78° E. Dip S. 60°.

HALT 80. N. E. ¼, S. E. ¼, Sec. 29, T. 63-13. Mica schist, fine, compact, but slaty and argillitic. Strike N. 70° E.

Rock 67. Argillitic mica schist.

HALT 81. S. W. ¼, N. W. ¼, S. 28, T. 63-13. Fine mica schist. Strike N. 69° E. Dip S. 63°. Glacial striæ S. 19° W.

HALT 82. S. W. ¼, S. W. ¼, S. 21, T. 63-13. Mica schist, characteristic. Would make good scythe-stones and good flagging. Breaks spontaneously into good shapes.

Rock 68. Mica schist, characteristic.

HALT 83. S. W. ¼, S. E. ¼, S. 21, T. 63-13. Nothing but light drift.

HALT 84. N. E. ¼, S. E. ¼, S. 21, T. 63-13. South point of large island. A very rocky shore with angles and isolated crags giving a most rugged aspect. Formation fundamentally a fine-grained but distinctly laminated schist. Strike N. 67° E. Dip 82°. Extensively intersected by granite intrusions. The general tendency of these is to conformability with the bedding; but they split and swell and branch in every conceivable manner. Here is one example.

The granite is mostly with very little mica. The swellings and some of the small connections are coarse granulyte in which

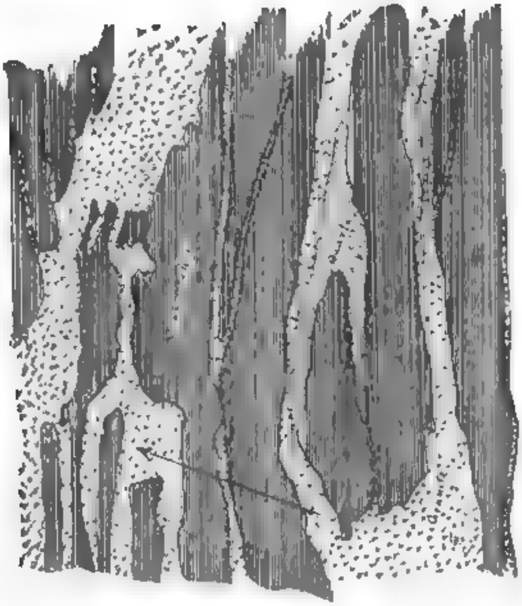

Fig. [illegible] Relations of Mica Schist and Granite at Halt 84, Burntside Lake. Surface [illegible] feet square

the quartz is very conspicuous and sometimes almost entirely displaces the orthoclase.

HALT 85. S. W. ¼, N. E. ¼, S. 21, T. 63-13. Enormous abutment of mica schist so cut up with intruded granite that half the mass is granitic.

HALT 86. N. W. ¼, N. E. ¼, S. 21, T. 63-13. N. W. point of same large island. Formation largely taken up with intruded granite. *A most interesting exhibition.* There is a distinct tendency of the granite to conform with the bedding, but it is nowhere exact. It lies in some places in great masses. It is of two kinds; one with reddish orthoclase and the other with whitish; but these do not appear to belong to two systems of injection. In the former, the feldspar much exceeds the quartz. In neither is mica conspicuous, even when present.

Notwithstanding the abundance of granite, the mica schist is everywhere distinctly laminated.

The granite and schist are mingled not only through abundance of granite injections, but by much interpenetration on a small scale. Portions of the rock are so ribboned with granitic and schistose ingredients irregularly succeeding each other, that the rock is literally schisto-granitic.

The appearance of this region indicates a gradual passage from mica schist into granite — not mineralogically, but structurally.

The bedding of the schists is often locally bent by the granite. Strike of beds N. 82° E.

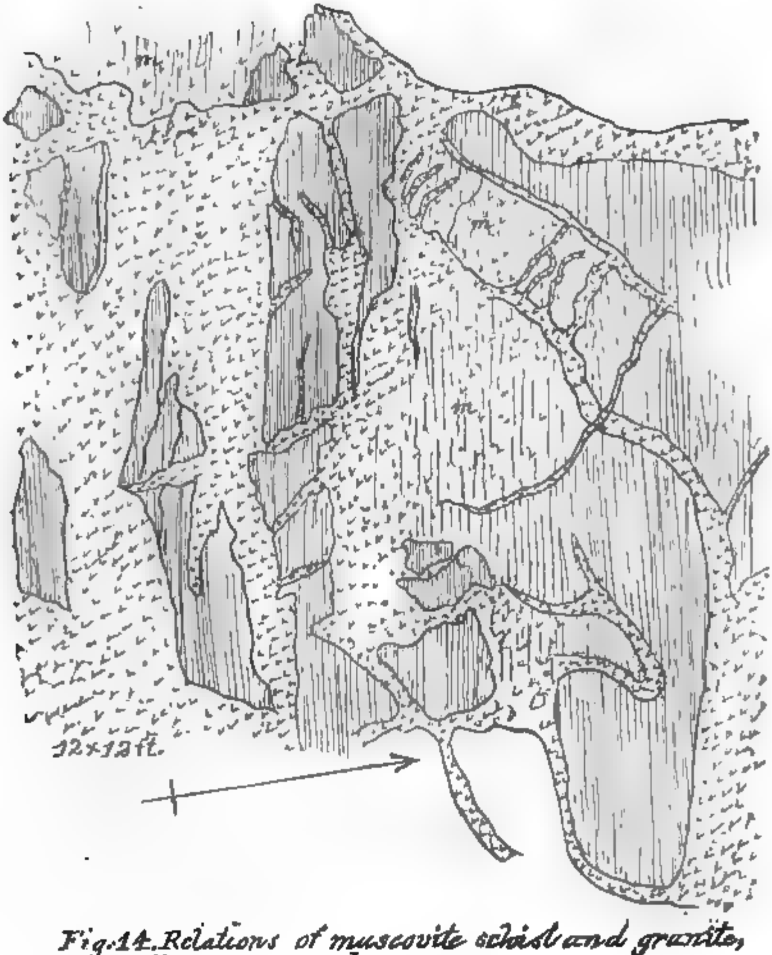

Fig. 14. Relations of muscovite schist and granite, Halt 86, Burnside Lake,
In the regions marked m the schist and granite are intricately mixed.

HALT 87. N. E. ¼, N. E. ¼, S. 21, T. 63-13. Northwesterly point of island. All a mass of mica schist permeated by granite. Dip vertical.

HALT 88. S. W. ¼, N. W. ¼, S. 22, T. 63-13. On the island. Mica schist with north dip of about 87°.

HALT 89. S. W. ¼, S. W. ¼, S. 23, T. 63-13. Main land. Boss of rock 100 feet high. Fundamentally fine, compact mica schist; in places having hundreds of veins of epidote traversing it, conformably with the bedding; also many veins of quartz similarly conformable, and others crossing the beds. Also veins of epidote across the bedding. Strike N. 63° W. Dip 66° S.

HALT 90. N. W. ¼, S. W. ¼, S. 23, T. 63-13. Rounded point of main land. A mass of granite. Considerable search is required to discover any schist whatever. The principal mass of the granite is a medium-grained biotite granite. This is intersected by two systems of granitic veins — one of which is fine-grained, with little mica, and the other a granulyte. The feldspar in all is light colored, and there is also some muscovite.

Of mica schist the only example found is about two feet wide. It is fine-grained, compact, brittle. It forms on two sides a sharp junction with the granite, but is in places penetrated by granitic intrusions. It approaches the character of a fine gneiss. I have traced this bed of schist about 60 feet, in a direction N. 71° E.

A hill rises in the rear, 75 feet high, but is covered by drift.

HALT 91. Centre of S. W. ¼, S. 23, T. 63-13. Great mass of hornblende schist, with considerable feldspar, intersected by quartzose veins mostly conformable with the bedding. Also by a dike of fine light-colored muscovite granite 2½ feet wide, striking N. 51° E. Strike of the schist, N. 69° E. Dip south but nearly vertical.

Adjoining this on the south the rock assumes the character of a syenitic gneiss, with much hornblende. This gneissic mass is extensively intersected by veins which are either quartzose, felsitic or epidotic — sometimes a felsitic vein being split by a quartzose one. The gneissic mass — so called — is properly a very massive hornblende schist.

In this part is a granite vein, nine inches wide, running with the strike, and having itself, on the weathered surface, structure lines parallel with the bedding planes of the schist. This vein is faulted twelve inches, and terminates abruptly in its eastward extension. It is not a proper granite, but a compact, fine-grained gneiss.

Rock 69. Hornblende schist, very massive.

Rock 70. Dike in the hornblende schist.

HALT 92. Centre of S. W. ¼ of S. 23, T. 63-13. Mica schist intersected by many veins of granite, granulyte and quartz. This is the whetstone rock, again, of Halt 82. Strike N. 86° E. Dip 50° S. near shore, 83° on the hill.

Embraced in the mica schist is a mass of light-colored granulyte surrounded by the schist on all sides, and embracing fragments of the schist, which still retain their laminated structure and their original position. See Fig. 15.

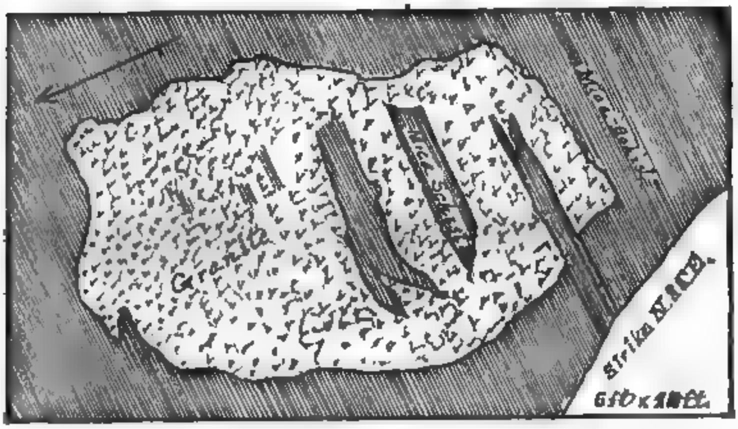

Fig. 15. Schist inclosing Granulite, itself embedding Mica Schist, Halt 92, Burntside Lake.

The granulyte contains also a layer of muscovitic hornblende schist.

HALT 93. N. W. ¼, S. E. ¼, S. 23, T. 63-13. Mica schist. Strike N. 60° E.

HALT 94. S. W. ¼, N. W. ¼, S. 24, T. 63-13. Mica schist, very distinctly thin bedded, but solid and ringing.

HALT 95. N. E. ¼, N. W. ¼, S. 24, T. 63-13. Boss of hydromica granite, but with hornblendic mica schist joining abruptly on the south.

Rock 71. Hydromica granite.

HALT 96. S. E. ¼, S. W. ¼, S. 13, T. 63-13. On island. Hydromica granite with coarse grains of quartz and white feldspar. Intersected by pinkish veins of vitreous granite without mica.

HALT 97. N. E. ¼, N. W. ¼, S. 24, T. 63-13. Main land opposite island. Hydromica granite exactly like last.

HALT 98. N. E. ¼, S. E. ¼, S. 13, T. 63-13. Hydromica granite.

HALT 99. N. W. ¼, N. E. ¼, S. 18, T. 63-12. Point of main land. Mass of granite through which pass beds of hornblende schist, having strike N. 78° E. One of these beds is 3 feet wide and can be traced 30 feet, when it disappears under the soil.

Rock 72. Granite from Halt 99.

Rock 73. Hornblende schist in bed embraced in granite.

HALT 100. N. E. ¼, N. E. ¼, S. 18, T. 63-12. Granite, but with inclusions of dike matter.

Rock 75. (See 74 at Halt 106.) Dike, at Halt 100.

HALT 101. S. E. ¼, N. E. ¼, S. 18, T. 63-12. Biotite granite, medium grained.

HALT 102. Island near east end of Burntside lake. Granite of light color exteriorly, intersected by veins of reddish granulyte. Here, also, is another bed of hornblendic matter appearing like a dike, and having some resemblance to a fine dioryte.

HALT 103. Near centre of S. 8, T. 63-12. Granite. Fundamentally hydromica granite of light color, but extensively intersected by dike-like beds of dioryte-like hornblende schist, and including some black chunks of fibrous hornblende schist.

This sort of granite continues southwestward along the lake shore.

HALT 104. North side S. 18, T. 63-12. Granite with many large quartz grains.

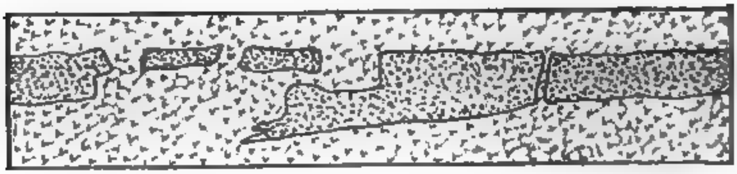

Fig. 16. Broken, dike-like form in Granite. Halt 104. Burntside Lake.

This is intersected by a dike-like intrusion of dark color, fine grain, appearing to be made up of hornblende and a feldspar, and having a very dioryte-like look. Still, these intrusions have reached this igneous aspect by so obvious a gradation from hornblende and mica schist, that one is led to believe the matter was once simple schist, then softened, altered and squeezed into fissures.

HALT 105. N. W. ¼, N. W. ¼, S. 18, T. 63-12. Extremity

of point or near it. At water's edge rock is largely fine dioryte, but on the hill it is the usual granite.

HALT 106. Twenty rods from S. end of island. Dioryte, coarse, containing black, lustrous hornblende and a pink feldspar. A handsome rock, suitable for fine architecture and monuments.

Rock 74. See 75, Halt 100. Dioryte (or hyposyenyte.)

HALT 352. N. W. ¼, N. W. ¼, S. 13, T. 63-13. Large island. Hydromica granite, medium grained.

HALT 351. S. E. ¼, S. E. ¼, Sec. 14, T. 63-13. Small island. Hydromica granite.

HALT 353. N. W. ¼, S. W. ¼, S. 13, T. 63-13. Small island. Hydromica granite with coarse, disseminated grains of quartz. In places these grains are one-fourth inch in diameter, and the reddish orthoclase is still coarser.

HALT 354. S. W. ¼, N. W. ¼, S. 13, T. 63-13. Small island. Hydromica granite and muscovite granite. At one place I observed a patch in which hornblende was the dark mineral. We still have coarse, disseminated quartz.

HALT 355. N. E. ¼, N. E. ¼, S. 13, T. 63-13. Mostly a hydromica granite, with coarse, disseminated grains of quartz. The longer dimensions of these grains lie in a direction N. 60° E. The rock is intersected by numerous veins of granulyte with reddish orthoclase. In some detached masses of granulyte, which I think are nearly in place, I find portions with reddish feldspar, portions with white feldspar, and other portions extraordinarily coarse. I see included, also, rounded masses of hornblende schist.

HALT 356. N. E. ¼, N. E. ¼, S. 13, T. 63-14. The principal rock is a biotite granite, but it is intersected by a dike of dioryte, which itself incloses many angular and rounded fragments of granulyte, and is also intersected by dikes of granulyte.

Rock 156. Biotite granite, somewhat hydromicaceous.

HALT 357. N. E. ¼, N. E. ¼, S. 13, T. 63-13. Mass of granulyte, very variable in texture, and presenting still further varieties in its veins and dikes. As exposed on the shore in a nearly vertical wall, it has the appearance of the ordinary bedded schists dipping N. at an angle of 70°. This illusory appearance is due to joints, which, with another set making an angle of 75° or 80° with these give the formation a columnar structure.

Rock 157. Hydromica granite from a portion of the above mass. This is a piece of a quadrangular prism.

I find a boulder here of a very remarkable character. It is a mass of quadrangular crystals of feldspar which unweathered are bluish, but on weathering assume a slightly pinkish tint. These are imbedded in a matrix of dark greenish matter, which, I think, must be essentially augite. The rock must be either diabase or noryte.

Rock 158. Noryte, as above.

HALT 358. N. E. ¼, N. E. ¼, S. 13, T. 63-13. Biotite granite. Intersected by veins of granulyte.

HALT 359. N. E. ¼, N. E. ¼, S. 13, T. 63-13. Medium-grained biotite granite. Contains a dike of fine dioryte fifteen inches wide and dipping N. 23°. The dike varies to coarser dioryte and is intersected by veins and dikes of granite. The dioryte contains a very large proportion of hornblende.

HALT 360. S. W. ¼, S. E. ¼, S. 12, T. 63-13. The rock at the beach is granite, varying from white to reddish, and to granulyte. A little back I find a band of dioryte. Then numerous bands, and more numerous as I proceed north, until the formation is two-thirds dioryte and one-third granite. The dioryte bands are substantially parallel with each other and strike N. E. Examining this bedded dioryte with a lens, I find no quartz and no mica; but further from the shore I see minute glistening specks which give a suspicion of mica, but nothing more.

Fig. 17. Relation of granite and hornblende schist, at Halt 360, Barntside Lake.

Rock 159. Granite.

Rock 160. Interbedded granite and dioryte.

Rock 161. Bedded dioryte.

At the distance of three hundred feet back from the shore (northward), the dioryte has developed a few small grains and laminæ of quartz which displaces part of the feldspar; and there are now present obvious laminæ of biotite, with a suspicion of muscovite.

The dark rock is now essentially a micaceous hornblende schist. It is interbedded with granulyte and strikes N. 80° E.

Rock 162. Micaceous hornblende schist.

In its contact with granite beds it adapts itself to the inequalities of the granite, as shown in figure 17. At some points the granite itself is a biotite gneiss.

I find, also, characteristic coarse-grained dioryte, but whether in dikes intersecting the bedding of the formation, or in conformable beds, I could not ascertain.

The formation has now become somewhat nondescript, consisting of perhaps one-fourth interbedded granite, nearly three-fourths slightly micaceous hornblende schist, and the remainder of syenitic gneiss and granular dioryte. In this mixed state it trends N. E. and forms a rocky range on the north side of the bay, attaining an altitude of fifty feet.

HALT 361. S. E. ¼, S. W. ¼, S. 12, T. 63-13. Here we see there markable structural features shown in Fig. 17. The formation is about half granite and half mica schist. The diagram shows the mode of transition. The rocky materials are more confused than at Halt 360.

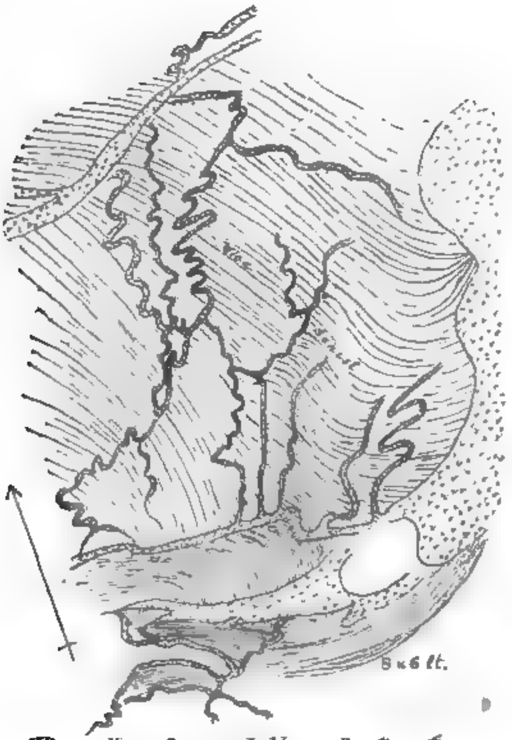

Fig. 18. View of remarkable rock-structure at Halt 361, Burntside Lake.

a. Reddish compact granulyte with a little muscovite.
b. Whitish granite with abundance of biotite.
c. Whitish biotite-granite.

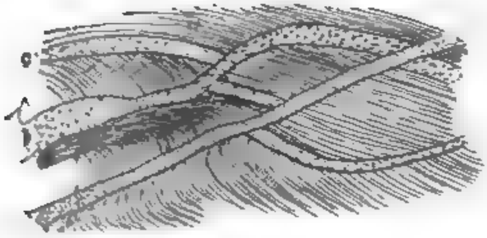

Fig. 39. Consecutive veins at Halt 364, Burntside Lake.
a. Reddish compact granulite with a little muscovite.
b. Whitish granite with abundance of biotite.
c. Whitish biotite granite.

A little back, the formation embraces a vein which looks much like a mass of diallage. It contains also a little mica.

Rock 163. Diallage (?) from a vein as above.

HALT 362. S. W. ¼, S. W. ¼, S. 12, T. 63-13. Granite and schist mixed, but with preponderance of granite.

HALT 363. S. E. ¼, S. W. ¼, S. 12, T. 63-13. Granite and mica schist mixed as before. The schist is fully three-fourths of the whole.

HALT 364. Centre S. W. ¼, S. 12, T. 63-13. Mica schist with much granite mixed in the form of veins and dikes.

HALT 365. N. E. ¼, S. W. ¼, S. 12, T. 63-13. More than half granite. The mica schist is variously interbedded as before. Also dioryte and syenite.

Rock 164. Granite with green feldspar. An enormous bluff sixty feet high.

HALT 366. N. E. ¼, S. E. ¼, S. 12, T. 63-13. Granite and mica schist.

HALT 367. N. E. ¼, S. W. ¼, S. 12, T. 63-13. Granite and mica schist.

HALT 368. S. W. ¼, S. W. ¼, S. 12, T. 63-13. Mica schist and granite — the former predominating. The schist is mostly very hard and very fine, but it is genuine.

HALT 369. S. W. ¼, S. W. ¼, S. 12, T. 63-13. Mica schist and granite with preponderance of schist. Here lies a detached mass on the top of a bluff, 12 feet high, 15 feet long and 11½ feet wide.

HALT 370. N. W. ¼, S. W. ¼, S. 12, T. 63-13. Granite and

mica schist — the granite ranging from one-fourth to two-thirds of the whole mass — varying with locality. Contains veins of epidote as a constituent in certain places.

HALT 371. N. E. ¼, S. E. ¼, S. 11. T. 63-13. In the stream entering from north. Granite and mica schist.

HALT 372. N. E. ¼, N. E. ¼, S. 11, T. 63-13. All granite, with feldspar ranging from reddish to white. I find, however, some dioryte schist interbedded.

HALT 373. N. W. ¼, N. W. ¼, S. 12, T. 63-13. Mostly granite, but with included masses of dioryte schist and micaceous schist. (For dioryte specimen see Rock 168.)

HALT 374. N. W. ¼, corner S. 12, T. 63-13. On creek. Could not land, but could see that the rock consists of granite and a dark bedded material.

HALT 375. N. W. ¼, N. W. ¼, S. 12, T. 63-13. Granite, all interbedded with biotite schist quite dioryte-looking on the weathered surface.

HALT 376. S. W. ¼, S. W. ¼, S. 1, T. 63-13. Granite and a dark rock which I guess to be mica schist, since I could not get to it.

HALT 377. S. E. ¼, S. W. ¼, S. 1, T. 63-13. Granite and mica schist about equal.

HALT 378. N. E. ¼, S. W. ¼, S. 1, T. 63-13. Entrance to Pretty lake. Gneiss of two varieties, interbedded with graywacke mica schist.

HALT 379. Near centre of S. 1, T. 63-13. Mica schist and granite as 3 to 1. The schist biotitic.

HALT 380. Near centre of S. 1, T. 63-13. Mica schist and granite interbedded, about 3 to 2. Large exposure.

HALT 381. N. E. ¼, S. 1, T 63-13. Mica schist mostly, but also granite and beds appearing like a mixture of biotite and augite.

Rock 165. Mixture of biotite and augite?

HALT 382. S. E. ¼, S. 36, T. 64-13. Mostly biotite schist, very compact and apparently diallagic.

Rock 166. Diallagic biotite schist (?)

HALT 383. S. E. ¼, S. 36, T. 64-13. Near extremity of Pretty lake. Rock largely gneissic, but with much mica schist. Here is a detached mass, hardly a boulder—35 feet by 21 feet by 15½ feet.

HALT 384. S. 36, T. 64-13. Extremity of Pretty lake. Mostly granite.

HALT 385. About on township line. Granulyte (coarse) and granite amazingly intermixed with a schist containing biotite and lamellar hornblende.

Rock 167. Schist from Halt 385.

Rock 168. Dioryte from Halt 373.

HALT 386. N. W. ¼, N. W. ¼, S. 23, T. 63-13. Island. Hydromica granite and nothing more.

HALT 387. S. W. ¼, S. W. ¼,S. 14, T. 63-13. Hydromica granite with some intermixture of mica schist. But the schist is not one-twentieth the whole mass. Schist fine and biotitic.

HALT 388. S. W. ¼, S. W. ¼, S. 14, T. 63-13. Granite mixed with typical mica schist and similar beds of dioryte schist about one-fourth. Some extensive beds are made of mica schist for a basis, but with imbedded lenticular lumps of a black color which are either hornblende or augite—also quartz sergegations and intersecting veins of granulyte.

Rock 169. Masses of hornblende as above.

HALT 389. S. part of N. E. ¼, S. 14, T. 63-13. Beds of granite and mica schist dipping conformably N. 75°.

HALT 390. N. E. ¼, N. E. ¼, S. 14, T. 63-13. Beds of granite and schist dipping N. 80°.

HALT 391. Near centre of S. 14, T. 63-13. *A remarkable exposure* 50 feet high, more than half schist, interbedded with granite.

Rock 177. Mica schist and granulyte interbedded—a most inadequate representation.

Here are some of the most convoluted veins yet seen, and I make a literal drawing of one in Fig. 20. The formation includes also chunks of dioryte and of augite rock. There ought to be half a dozen photograpic views taken.

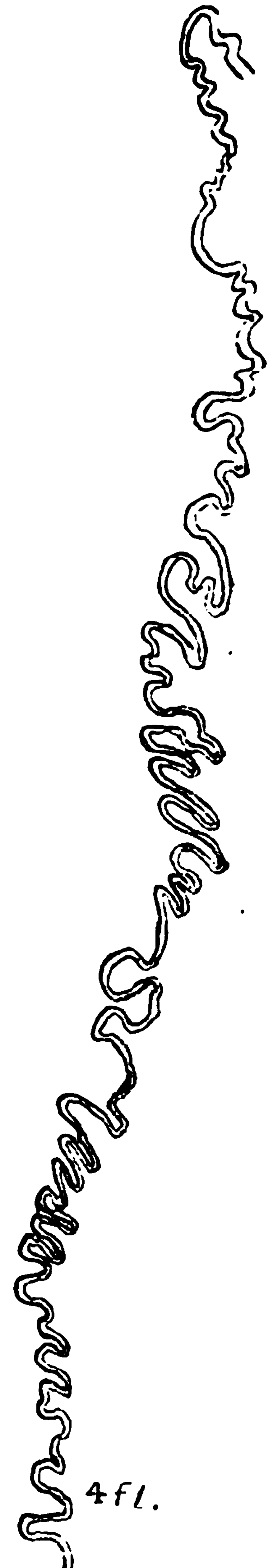

Fig. 20. Vein of granulite at Halt 391, Burntside Lake. Continues 15 feet.

HALT 392. S. W. ¼, N. W. ¼, S. 14, T. 63-13. Mica schist and granite interbedded and intertwisted. Over half schist. Contains, also, masses of dioryte.

HALT 393. N. E. ¼, S. 15, T. 63-13. Granite and mica schist in proportion of two to three.

HALT 394. N. E. ¼, N. W. ¼, S. 15, T. 63-13. Mica schist, extensively intersected by veins of granite.

HALT 395. S. W. ¼, S. W. ¼, S. 10, T. 63-13. Mica schist extensively veined with granite. Some of the schist is hornblendic. Some dioritic schist is here.

HALT 396. Near centre S. 10, T. 63-13. Mica schist and granite as 4 to 1.

HALT 397. N. W. ¼, N. E. ¼, S. 10, T. 63-13. Mica hscist and granite 4 to 1.

HALT 398. N. E. ¼, S. E. ¼, S. 3, T. 63-13. Mica schist and granite as 5 to 2. The bedding is quite distinct, dipping N. 75°. The beds show increased tendency to separate, and we get some even laminæ half an inch to an inch in diameter.

HALT 399. S. W. ¼, S. W. ¼, S. 35, T. 64-13. Granite in about equal proportions with a black rock material apparently composed chiefly of lamellar hornblende or augite, with some scales of biotite.

Rock 171. Dioryte schist as above.

HALT 400. S. E. ¼, S. W. ¼, S. 34, T. 64-13. Coarse muscovite-gneiss. It contains a place folded around, as below:

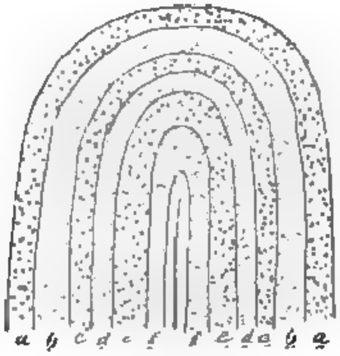

Fig. 21. Fold in the bedded rocks at Halt 400, Burntside L.
a, c, e, Coarse cherty.
b, d, f Fine cherty.

Rock 172. Large crystals of orthoclase.

Rock 173. Very coarse and muscovite-gneiss.

HALT 107. N. W. ¼, S. E. ¼, S. 23, T. 63-13. The rock here is a very compact dioritic schist. with very obscure bedding.

Rock 76. Compact dioritic schist.

The portage to Long lake leaves Burntside at this place.

HALT 108. S. E. ¼, S. E. ¼, S. 23, T. 63-13. On portage. Graywacke schist, very compact and hard, with many flinty veins. Strike N. 82° W. Dip. S. 45°. Portage from Burntside lake to creek into Long lake is about ¼ mile and good except at end, which is wet.

HALT 109. S. W. ¼, S. W. ¼, S. 24, T. 63-13. Entrance to Burntside river. Bosses of rock fifty feet high. Hydromica schist, compact, irregularly laminated, with many knots of feldspathic and siliceous matters. Contains also, moderate sized masses of flint and cherty material. Strike N. 50° E. Dip S. 82°.

Rock 77. Hydromica schist.

HALT 110. S. W. ¼, S. E. ¼, S.24, T. 63-13. High outlier, 50 feet high. Graywacke, dark gray, with small feldspar nuclei and a dark and augitic mineral.

Rock 78. Graywacke from Halt 110, Burntside river.

§ 7. LONG LAKE.

Long lake lies wholly in the southern half of T. 63-12. Its main axis is N. 66° E., which is a greater inclination to the meridian than in the case of Burntside lake, and greater than is the case with the smaller lakes in the northern half of this township. The lake is about four miles long and three quarters of a mile broad, if we disregard the large bay upon the northwestern border. It is freer from islands than Burntside, but the rocky outcrops along the shore are nearly continuous. Ranges of rocky hills lie upon the north, but with trends somewhat less divergent from the meridian than the axi of the lake, and, in consequence, they approach the lake in their westward continuation. The direction of one of these ranges crosses the lake along the region connecting with the bay just mentioned, and its course is marked by a number of islands. The lake, on the whole, is excavated in the vertical edges of a mass of schists mostly sericitic, but in places chloritic, and occasionally replaced by graywake.

HALT 111. N. E. ¼, N. E. ¼, S. 30, T. 63-12. S. E. corner of

Long lake. Hydromica schist, dark greenish, compact, with an argillaceous aspect; weathering pale, yellowish greenish. Strike N. 60° E. contains a dike-like mass of a similar material, but weathering light, and with a very fibrous structure, striking N. 33° E. The fibres are so conspicuous as to present the appearance of a mass of *lignilytes.* This dike is 2½ feet wide.

Rock 79. Hydromica schist.

Rock 80. Fibrous hydromica schist in a dike.

HALT 112. N. W. ¼, N. W. ¼, S. 29, T. 63-12. Sericitic schist, but very similar to Halt 111. Strike N. 70° E. Many quartz veins. Dip S. 70°.

HALT 113. N. E. ¼, N. W. ¼, S. 29, T. 63-12. On a little island. Sericitic schist—same as on Vermillion lake. Strike N. 70° E.—and this is the trend of the island. Dip S. 75°. Some narrow beds of whitish, fibrous hydromica material, as at Halt 111—but here conformable with the bedding.

Rock 81. Sericitic schist, pale greenish.

HALT 114. S. W. ¼, N. W. ¼, S. 29, T. 63-12. Point of main land. Chloritic sericitic schist, in places weathering to a pudding-stone aspect.

HALT 115. Island east of Halt 114. Chloritic sericitic schist, very compact. Dip S. 75°.

HALT 116. S. E. ¼, N. W. ¼, S. 29, T. 63-12. Island north of point. Fine, compact dioryte, but with the weathered aspect of a sericitic schist. The bedding is very obscure, and runs with the island. This is 125 feet wide, and the rock is of the same character from side to side.

Rock 82. Fine dioryte (?) from Halt 116.

HALT 117. N. W. ¼, S. W. ¼, S. 29, T. 63-14. Island close to point. Rock feebly schistose, in large part having a dioritic look, but in places somewhat like chloritic graywacke. The whole is only moderately hard.

Rock 83. Dioritic schist.

HALT 118. N. W. ¼, S. W. ¼, S. 29, T. 63-12. Graywacke schist, but very solid.

HALT 119. N. W. ¼, S. W. ¼, S. 29, T. 63-12. Graywacke schist in high bluff and intersected by veins of quartz.

HALT 120. Centre S. E. ¼, S. 30, T. 63-12. Sericitic schist in high cliff.

HALT 121. S. E. ¼, S. E. ¼, S. 30, T. 63-12. Graywacke schist.

HALT 122. N. W. $\frac{1}{4}$, S. W. $\frac{1}{4}$, S. 29, T. 63-12. Little island opposite Halt 121. North side a compact sericitic schist holding fragments of quartz porphyry,—and also fragments of porphyry—the whole of this having a fine brecciated aspect, as shown in the following diagram:

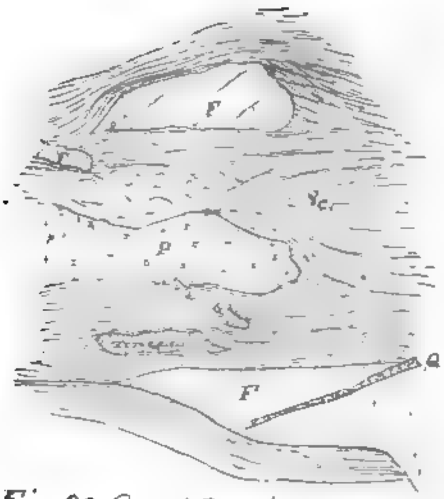

Fig. 22. Quasi-brecciated formation at Halt 122, Long Lake. F. felsite. Porphyry similar to F. Q, quartz. Sc. sericitic schist.

The laminæ are wrapped around the fragments of felsitic material exactly as if sedimentary.

The sericitic schist presents very diversified aspects; in places weathering greenish, in others whitish. Mostly it is free from hornblende, but in places crystals, of fibrous, dark-greenish hornblende lie imbedded in it—the longer dimensions mostly transverse to the lamination.

On the southeast side of the island, the formation changes to argillyte distinctly laminated and characteristic. The passage, however, is gradual. Dip S. 82°.

Rock 84. Sericitic schist porphyritic with hornblende.

Rock 85. Argillyte.

Rock 86. Sericitic schist.

HALT 123. Small island south side of bay. Chloritic argillyte. Dip S. 82°. Contains in joints a white mineral with transverse fibrous structure.

Rock and mineral 87. Chloritic argillyte.

HALT 124. S. W. ¼, S. E. ¼. Sec. 29, T. 63-12. Island. Pure, smoothly laminated sericitic schist, light colored, buffish.

Rock 88. Light, smooth sericitic schist, leather colored.

HALT 125. N. W. ¼, N. E. ¼, S. 32, T. 63-12. Island. Graywacke schist.

HALT 126. S. E. ¼, S. E. ¼, S. 29, T. 63-12. Main land. Finely mottled sericitic schist, crumbling into small scales under atmospheric action, forming a ridge 30 feet high which ranges with the schistose structure N. 39° E.

Rock 89. Sericitic schist finely mottled.

HALT 127. S. E ¼, S. E. ¼, S. 29, T. 63-12. Argillyte standing vertical, and graduating southward into the sericitic schist last seen. Schistosity strikes N. 20° E.

Rock 90. Argillyte.

In passing the angle of the land, we see a fine outcrop of argillitic sericitic schist. Further along, on the shore facing N. W., the same occurs.

HALT 128. N. E. ¼, S. E. ¼, S. 29, T. 63-12. South end of island. Sericitic schist, standing vertical and striking nearly north.

HALT 129. N. E. ¼, S. E. ¼, S. 29, T. 63-12. Main land. At the point, the argillyte stands like sheets on edge, 20 feet high.

HALT 130. S. W. ¼, S. W. ¼, S. 28, T. 63-12. Island, south end. Graywacke. The north end of the island is of sericitic schist.

HALT 131. Near centre of S. 28, T. 63-12. Sericitic schist, compact, irregularly laminated, chloritic.

HALT 132. Near centre S. 28, T. 63-12. Graywacke, so-called.

HALT 133. S. W. ¼, N. E. ¼, S. 28, T. 63-12. Sericitic graywacke, very fine.

HALT 134. S. W. ¼, N. E. ¼, S. 28, T. 63-12. Chloritic graywacke schist, bluish-green.

HALT 135. Centre of N. E. ¼, S. 28, T. 63-12. About same as last. Has quartz veins and pale green feldspar of pyrites.

Rock 91. Chloritic Graywacke.

HALT 136. S. W. ¼, S. W. ¼, S. 23, T. 63-12. Argillyte, fine grained, evenly laminated but compact.

Rock 92. Argillyte.

HALT 331. N. E. ¼, S. E. ¼, S. 22, T. 63-12. Yellow sericitic slates.

HALT 332. Near centre of section 22, T. 63-12. Chloritic sericitic schist — compact and rugged.

HALT 333. Near centre S. W. ¼, S. 22, T. 63-12. Sericitic schist, greenish, warped, rough weathering, chloritic. Strike N. 61° E. This is exactly the same as we saw at Halt 329. The harsh-weathering surface shows countless veins of quartz, felsyte and epidote, having a prevailing direction with the strike, but not at all conformable.

HALT 334. N. E. ¼, S. W. ¼, S. 22, T. 63-12. Chloritic schist, bluish, thin laminted.

Rock 152. Chloritic schist, somewhat sericitic.

Back of this, rock of Halt 333 recurs, making a thickness here of 300 feet.

We find great zones of dike-like aspect, in this formation; but they run, in some places, in exact conformity to the bedding, of varying width annd irregular walls. In one place I see one of these masses terminate in quartz and strike off diagonally across the bedding. These zones have, in places, a graywacke-like aspect and a schistose structure, and, when closely examined, show glistening, minute, white scales which I do not take for mica, but more probably damourite. But the mass of the dike has about the hardness of feldspar, and it appears like a mass of micaceous folia in a nascent — not well defined — state. I find here also, veins apparently of dolomite.

Another class of dike-like zones is silicous. They sustain about the same relation to the bedding as the dikes just mentioned. They range from rugged-weathering quartz to petrosilex.

Rock 153. Petrosilex as above.

This formation in all respects resembles that seen at Halt 321 — but is not identical — having a predominantly greenish color.

HALT 335. N. W. ¼, S. W. ¼, S. 22, T. 63-12. A hill at least 200 feet high separated by a thicket and a swamp from Halt 334. Did not visit it because it trends toward the lake and I expected to see it further west.

HALT 336. S. E. ¼, S. W. ¼, S. 2, T. 63-12. Little island. Sericitic schist, shaly and crumbling — not entirely smooth, but with small specks, as before seen.

HALT 337. S. W. ¼, S. W. ¼, S. 21, T. 63-12. Gnarled chlorite schist.

HALT 338. N. W. ¼, S. W. ¼, S. 21, T. 63-12. Gnarled chlorite schist.

HALT 339. S. E, ¼, S. E. ¼, S. 20, T. 63-12 Chlorite schist with many lenticular calcitic layers. Color green. Strike N. 81° E.

HALT 340. S. E. ¼, S. E. ¼, S. 20, T. 63-12. Island. Chloritic graywacke schist.

HALT 341. S. E. ¼, S. E. ¼, S. 29, T. 63-12. Inlet. Chloritic graywacke schist.

HALT 342. S. E. ¼, S. E. ¼, S. 20, T. 63-12. Compact chloritic graywacke schist.

HALT 343. N. E. ¼, S. W. ¼, S. 20, T. 63-12. Graywackenitic chlorite schist. The rock is of a greenish color, not conspicuously schistose, consisting of dark greenish chloritic material, in which appear many undefined crystals of a greenish feldspar apparently in a nascent state.

Rock 154. Wackenitic chlorite schist.

The rock is intersected by veins of granulyte with a little hydromica, and dikes of augite.

Rock 155. From an augite dike.

This resembles that seen on the west side of White Iron lake, but is harder.

These rocks rise in a conspicuous knob fifty feet above the lake, and trend northeast toward a hill seventy-five feet high. The strike of the range is N. 73° E., and I am quite certain the high hill of Halt 835 is here on the lake shore as was to be anticipated.

HALT 344. Centre of S. 20, T. 63-12. Blue, hard, much jointed chloritic rock.

HALT 345. ¼ mile W. of centre S. 20, T. 63-12. Chloritic graywacke schist.

HALT 346. N. E. ¼, S. W. ¼, S. 19, T. 63-12. Graywackenitic chlorite schist, irregular, compact and hard.

HALT 347. S. W. ¼, S. W. ¼, S. 19, T. 63-12. Chloritic argillyte. Dip S. 78°.

HALT 348. S. W. ¼, S. W. ¼, S. 19, T. 63-12. Argillitic chlorite schist.

HALT 349. S. W. ¼, S. E. ¼, S. 19, T. 63-12. Chloritic graywacke schist.

HALT 350. S. W. ¼, S. E. ¼, S. 19, T. 63-12. Argillitic chlorite schist.

The portage eastward out of Long lake is at the eastern ex

tremity. It is uncommonly good as far as the border of the marsh — dry, direct and smooth. It is almost a sort of turnpike. In the marsh the trail divides, one branch going directly to the creek and the other striking the creek further along. This part of the trail is exceedingly wet. The dry part is three-quarters of a mile long; the wet part one-third of a mile. The last third of a mile of the creek will take a canoe.

§ 8. FALL LAKE.

Fall lake lies chiefly in the northern half of T. 63-11. Its main axis trends N. 64° E., and is very nearly in continuation of that of Long lake. Its extreme length is about six miles, and mean breadth about two-thirds of a mile. It swells to a mile towards each extremity, while in the middle region, there are two places where the width is contracted to about one-sixth of a mile.

This is a very beautiful lake, but for scenic effects scarcely equal to Burntside. From the rounded point near the inlet of Fall river (Halt 290) the view down the lake northeastward embraces three or four miles, and the alternating vistas of land and water in the distance, produce a very pleasing effect. The falls near this point begin to acquire some celebrity, and when the means of access become easy, they and the fine lake will constitute a decided attraction for tourists. The stream in which the falls are situated comes in from Garden lake and carries the water which accumulates from Garden, Farm and White Iron lakes, as well as that from Birch and Stuntz lakes. The Kawishiwi river also empties into Farm lake, and this receives the drainage from an extensive region stretching to lakes Wilder and Isabella, in range 8. Fall river, therefore, is a stream of importance. The falls are known to the Indians as Ka-wa-sa-chong falls. They have also been called Cara Belle falls.

The falls as a scenic spectacle are very grand. The total descent is about thirty-five feet, and the volume of water, even in July, is surprisingly large. The fall is not one perpendicular plunge, but over the ragged wall of a precipice, which, on the east side, carries the water forward about fifteen feet, and on the west side, forty-five feet. The stream is divided about equally by a projecting rock-mass, and the portion on the west is again divided about ten feet down.

The entire volume of water is broken into a fury of foam and presents a spectacle of impressive grandeur. The roar of the

falls can be heard at the distance of two or three miles. As a natural phenomenon, these falls are all that the mind can duly appreciate. They are grander than Minnehaha, and the volume of water is eight times as great.

The water of the lake is clear and palatable. Like that of the other small lakes of the region, it rapidly acquires the mean seasonal temperature of the air — being rather warm during summer, but promptly cooling with the advent of autumnal weather. This lake, also, is well stocked with fish — especially pickerel, pike and bass.

The shores are generally less elevated than those of Burntside lake, and occasional short intervals of low and even marshy border occur. Generally, however, the shore is rock-bound and the facilities for geological study are ample. The rocks are very generally sericitic schist; but this in places, becomes chloritic or argillitic, or a strongly marked rudely-bedded, or even unbedded, chloritic rock, as at the falls. The bedding is everywhere approximately vertical. The general geology closely resembles that of Long lake, as would be inferred from its similar relations to the strike of the schists, and the coincidence in the lines of axis of the lakes.

Though the growing season must be short, the development of vegetation is luxuriant and rapid. I noticed several white pine trees of magnificent proportions — some attaining even a diameter of three feet. Considerable Norway pine occurs also, but the forest, where not burned off, consists of a mixed growth, including the aspen, the yellow and white birch, white cedar, spruce and fir. The luxuriance of some of the shrubs is rather astonishing. The mountain maple (*Acer spicatum*) grows everywhere most rankly, and rapidly chokes all neglected trails. I measured in one instance, on July 24th, a shoot of this season's growth, 4½ feet long. At the same time and place a red-berried elder shoot (*Sambucus pubens*), of this season's growth, measured 6 feet and 7 inches to the base of the terminal petiole, and 23 inches more to the tip of the leaf. Probably, under suitable cultivation, many crops will attain, in the vicinity of Fall lake, a very satisfactory development.

HALT 137. N. E. ¼, N. E. ¼, S. 34, T. 63-12. On town line, near western extremity of Fall lake, south shore. By the water's edge, an outcrop of brownish-buff sericitic schist, exactly the same as at Halt 124. In some of it is a tinge of red. This rock continues along the shore eastward.

HALT 138. S. W. ¼, S. W. ¼, S. 18, T. 63-11. Little island. Sericitic schist, bluish, crumpled and somewhat knotted — a little argillitic.

Main land around this southern bay presents no outcrop. Surface generally 20 to 30 feet high, covered with aspen, birch and spruce.

HALT 139. Near centre of S. 19. Main land. Sericitic schist, brownish, moderately compact, much like that at Halt 138.

HALT 140. Near centre of S. 19, T. 63-11. Point of land. Sericitic schist, like Halts 138 and 139. Does not split up in weathering, but presents a knotted and very irregular black surface.

As it has been suggested that a dike of diabase occurs at this place, with schist each side, I revisited the locality for the purpose of more particular study. The schists which I at first described as sericitic, are chloritic-sericitic, and weather in a ragged fashion, much like those at the falls. The dike, so called, strikes nearly with the schists — perhaps precisely so — but seems to dip southward at an angle of about 70°. The matter of the dike is diabasic in appearance — but yet is somewhat chloritic, and presents a resemblance to the schist. It is not certainly bedded, but there are lines of lamination, which, however, may be fluidal in character. Simple macroscopic observation will not probably suffice to decide whether sedimentary or not.

Rock 292. From the schist above described.

Rock 293. From the so-called dike at Halt 140.

HALT 141. S. W. ¼, N. E. ¼, S. 19, T. 63-11. Sericitic schist, but still more blue and more compact — verging toward graywacke schist. Somewhat chloritic.

HALT 142. N. W. ¼, N. W. ¼, S. 20, T. 63-11. Sericitic schist, compact, crumpled, bluish and olive — a little back, more massive, approaching graywacke schist.

HALT 143. S. W. cor. S. 17, T. 63-11. Main land. Sericitic schist, rather slaty, greenish-brown, like Halt 139.

HALT 134. S. W. ¼, S. W. ¼, S. 17, T. 63-11. Sericitic schist, compact, bluish and chloritic, much like Halt 142. Contains veins of felsyte.

HALT 297. S. W. ¼, S. E. ¼, S. 17, T. 63-11. A very compact and felsyte-like rock, firmer and finer than has heretofore been called graywacke.

Rock 146. Felsitic schist.

HALT 298. S. W. ¼, S. E. ¼, S. 17, T. 63-11. Chloritic graywacke schist.

HALT 299. N. W. ¼, S. W. ¼, S. 16, T. 63-11. Yellowish sericitic slates, much like Halt 292. The rock is thin-laminar, but the laminæ are somewhat wavy, from the interlamination of compact, rather hard, thin lenticules of siliceous matter. A few steps southward the rock is more evenly bedded and more greenish. Great slabs separate, which are five feet long, while not more than two feet wide, and three inches thick, as a maximum.

Between the wavy and the plain laminated beds is a little unconformity, like this:

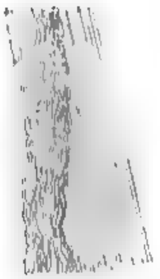

Fig. 23. Surface unconformity at Halt 299. Fall I.
Vertical Wall.

"This, however, is a surface phenomenon. Strike N. 40° E.; further west, N. 48° E. Dip of plain slates, S. 75°. The plain slates appear to assume a less steep attitude as they pass out of sight.

These slates are traceable along the beach, trending N. 21° E., for a distance of 402 feet. On the south they disappear under the earth. On the north they graduate into an irregular, unevenly bedded, chunky, sericitic schist, of a beeswax color. They might properly be styled *sericitic* schists.

HALT 300. S. W. ¼, N. W. ¼, S. 16, T. 63-11. Sericitic slates very similar to last. They seem to strike across the point and outcrop on both sides.

HALT 301. S. E. ¼, N. W. ¼, S. 16, T. 63-11. Sericitic slates, like last two Halts.

HALT 302. S. W. ¼, N. E. ¼, S. 16, T. 63-11. Sericitic slates, considerably rougher, with segregations of peroxide of iron. Strike N. 58° E. Dip S. 75°.

HALT 303. N. E. ¼, N. E. ¼, S. 16, T. 63-11. Sericitic schist, a little argillitic. Does not split in weathering. Strike N. 53° E. Dip S. 78°.

Rock 141. Sericitic schist, a little argillitic.

HALT 304. S. W. ¼, S. W. ¼, S. 10, T. 63-11. Sericitic schist exactly like last. Strike N. 48° E. Dip S. 86°.

HALT 307. S. W. ¼, S. E. ¼, S. 10, T. 63-11. Small outcrop of chlorite sericitic schist, massive and very unevenly bedded, having a bluish color. The stream marked on the plat as entering near here is not canoeable. I sought in the vicinity for a trail to the little lake in secs. 14 and 15, as I was informed that "black slate" occurs on the south side. But no trail could be found.

HALT 308. S. E. ¼, N. E. ¼, S. 10, T. 63-11. Mostly argilitic sericitic schist. At some points along the exposure, the rock is a graywacke schist, but it immediately passes into a smooth argillyte, and then eastward to an argillyte with sericitic surfaces and numerous grains disseminated, which give a pustulose surface, but are not distinct enough for determination in the field.

Rock 144. Sericitic argillyte with pustulose surface.

At the east extremity of this exposure are warped sericitic schisst, standing on edge and striking east and west.

HALT 309. S. W. ¼, N. E. ¼, S. 10, T. 64-11. Sericitic schist, warped and irregular and rather compact.

HALT 310. N. W. ¼, N. W. ¼, S. 11, T. 63-11. Exceedingly fine-textured sericitic argillyte. Strike N. 60° E.

Rock 145. Sericitic argillyte.

It is rather hard, apparently from the presence of finely disseminated feldspar.

HALT 311. N. W. ¼, N. W. ¼, S. 11, T. 63-11. Islet. Compact, irregular, bluish sericitic schist.

HALT 312. N. W. ¼, N. W. ¼. S. 11, T. 63-11. Sericitic schist with disseminated and undefined spots of bluish color and considerable iron, apparently limonitic.

Rock 146. Sericitic schist as above.

HALT 313. S. W. ¼, S. E. ¼, S. 2, T. 63-11. Sericitic schist, somewhat waxy and quite slaty.

Rock 147. Sericitic schist as above.

HALT 314. N. E. ¼, S. E. ¼, S 2, T. 63-11. Sericitic schist, a little more waxy than the last.

HALT 315. S. W. ¼, S. W. ¼, S. 36, T. 63-11. A high and

abundant outcrop of sericitic rocks. A good amount of variety. We have fine sericitic schist and bluish chloritic sericitic schist, and sericitic conglomerate, in which a fine sericitic schist weathering olive and fibrous, is filled with angular fragments of a material entirely similar, but more vesicular on the weathered surface — being crossed by innumerable interlacings of felsitic material. Some of these fragments are decidedly felsitic and some are graywacke-like in aspect.

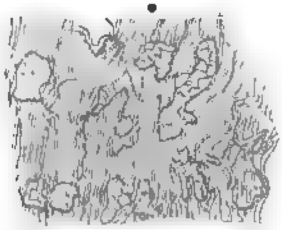

Fig. 24, Pseudo-conglomerate, Halt 315, Fall Lake
Horizontal surface

Careful study of this rock shows the fibres of the matrix adapting their direction to the form of the included masses, showing that these were deposited while the sediment was falling down.

At the same time, this is not completely a conglomerate, for we have: 1st, a common matrix in which these forms appear; 2d, these forms are so nearly of the mineral character of the matrix that they seem to be portions of the same rock; 3d, some of these forms blend insensibly with the matrix and look somewhat like segregations.

Rock 148. Sericitic pseudo-conglomerate, Halt 315.

It was impossible to get a standard specimen of a very characteristic one.

There is considerable quartz in the formation, partly disseminated and partly segregated.

Strike N. 55° E. Dip 90°.

HALT 316. S. E. ¼, S. W. ¼, S. 35, T. 64-11. Sericitic schists scarcely outcrop, but are abundant in somewhat slaty fragments.

HALT 317. S. E. ¼, S. W. ¼, S. 35, T. 64-11. Sericitic schist with chloritic spots. Strike N. 55° E. Dip 85° N.

Rock 149. Sericitic schist with chloritic spots.

HALT 318. S. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, S. 35, T. 64-11. Sericitic schist, same as last.

HALT 319. N. E. $\frac{1}{4}$, S. E. $\frac{1}{4}$, S. 3, T. 63-11. Sericitic schist, quite slaty. Dip N. 85°.

HALT 320. S. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, S. 3, T. 63-11. Sericitic schist with thin wavy laminæ and numerous disseminated undefined spots, as if some mineral were in process of disappearance. Strike N. 70° E. Dip N. 85°.

A few rods north it becomes regular, and very much seamed by quartz. Then, still further, it changes to waxy, rough sericitic schist.

HALT 321. S. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, S. 3, T. 63-11. Chloritic felsitic schist. Much and irregularly laminated, and weathering to white, bluish-green, black and purple. I have seen the same on Vermilion lake. The fresh-broken surfaces are predominately greenish—the weathered ones dun-whitish. Strike N. 55° E. Dip 85°.

HALT 322. S. E. $\frac{1}{4}$, N. W. $\frac{1}{4}$, S. 10, T. 63-11. Big island. Sericitic schist. Uneven layers. Strike N. 45° E. Dip N. 85°.

HALT 305. N. W. $\frac{1}{4}$, S. E. $\frac{1}{4}$, S. 9, T. 63-11. Buffish sericitic schists, not exactly like those on south shore.

These are not so smooth, but show a granular tendency. They are pervaded by minute grains appearing feldspathic. On weathered surfaces they dissolve out, giving the surface a finely cellular aspect.

Rock 142. Sericitic schist with small greenish grains.

In some parts are irregular laminæ of quartz. This rock is is in progress of transition, northward, into some other rock. This is like the schist of Halt 291.

HALT 306. S. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, S. 9, T. 63-11. Sericitic schist exactly like the last.

Rock 143. Sericitic schist from Halt 291, which I revisited to see if it is like that of Halt 305.

HALT 291. S. E. $\frac{1}{4}$, N. E. $\frac{1}{4}$, S. 18, T. 63-11. Sericitic schist, thin bedded, in wavy layers, soft and yellowish. Standing vertical like 305. Strike N. 55° E. The rock is 143, which see.

HALT 292. N. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, S. 18, T. 63-11. Sericitic schist like last, but more even.

HALT 293. An eighth of a mile north from Halt 292. Compact chloritic sericitic mass, little schistose.

HALT 294. A few rods north of last. Compact, firm, but

not very fine-grained, sericitic schist — massive, little schistose. In an elevated rocky ridge extending parallel with shore. Close by, the strike is N. 54° E., and the rock a more distinctly bedded sericitic schist.

HALT 295. One half mile north from Halt 292. Chloritic sericitic schist, very compact, imperfectly bedded, much intersected by veins of similar material which show lines of structure parallel with the wall.

A little further north is an outcrop in which the vein-material, shown in figure 24, is so much expanded as to form more than half the bulk of the rock, and the formation appears like a very coarse conglomerate.

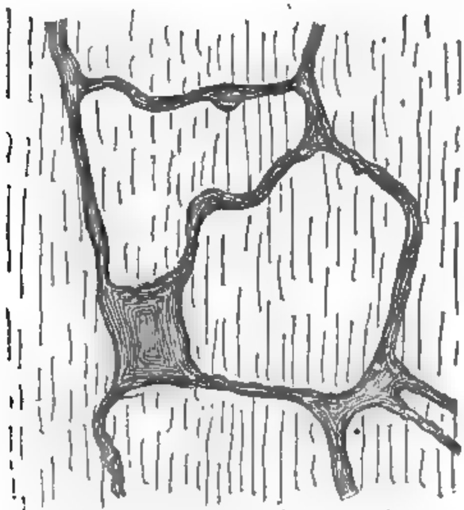

Fig. 25. Plan of veins at Halt 295, Fall Lake.

HALT 295 *bis.* N. W. ¼, S. W. ¼, S. 18, T. 63-11. Nearly half a mile back from the shore at Halt 292. Here a compact sericitic rock is interbedded with flint, but the layers are bent around so as to strike nearly north and south, or even west of north.

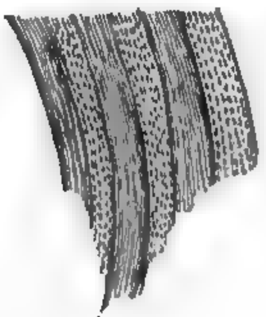

Fig. 26. Interbanding of flint and sericitic schist at Halt 295 bis, Fall Lake.

A few rods west, the formation is a massive graywacke rock, filled with ramifications of quartz, and containing irregular masses of rather soft, greenish rock.

HALT 296. A few rods west of Halt 295 *bis*. Outcrop of banded iron jaspilite—small, and not giving evidence of valuable ore—though evidently heavy ore may lie in close contiguity. I am told that this indication has been traced as far as the range line—about seven hundred and fifty paces west.

It is here in contact, on the north, with a sericitic schist containing a black mineral looking like columns of hornblende, or even tourmaline.

Rock 139. Sericitic schist and black crystals.

HALT 323. N. E. ¼, S. W. ¼, S. 18, T. 63-11. On the shore. Knotted, lumpy, chloritic sericitic schist.

HALT 324. Twenty rods west of Halt 323. Same as last. A range of rocks of this character stretches along the lake shore here, and strikes inland to Halts 293, 294, 295 and 296. The range here is about forty feet high.

HALT 325. Near township line. Well laminated sericitic schist, but with layers of a quartzose character, and others which appear to be dolomite. Color yellowish. Strike N. 60° E.

Rock 150. Sericitic schist, as above.

HALT 326. On township line. Sericitic schist, blue, with many layers hardened by deposition of (apparently) feldspar.

Rock 151. Sericitic schist, blue.

HALT 327. S. E. ¼, S. E. ¼, S. 13, T. 63-12. Gnarled sericitic chloritic schist, with layers of feldspar.

Rock 151 *bis*. Sericitic chloritic schist.

HALT 328. S. E. ¼, S. E. ¼, S. 13. T. 63-12. Sericitic chloritic schist, same as last.

HALT 329. S. E. ¼, S. E. ¼, S. 3, T. 63-12. The bluish sericitic schists graduate into greenish schists rough to the touch and giving a suspicion of fine mica. A few rods further south we have a very compact, fine-grained, greenish, felsitic schist, weathering dun-white and checked by joints and veins. Same as at Halt 320.

Included in this is a mass of graywacke-like rock weathering harsh, and including in itself some large lumps of iron jaspilite, in many cases bordered by films of epidote. The epidote intersects this mass also, in the form of veins. This graywacke-like mass is rudely conformable with the bedding of the formation, and occurs at two different horizons fifteen feet apart. The iron schist, however, is found only in the northern and older one. The range of iron schist seen at Halt 296, lies still further north.

Back of the last (that is, probably, northwest) come again bluish, rough sericitic schists with inter-laminations of feldspar, and some seams or veins or similar matter not conformable with the bedding, and with lamination conformable with the bedding of the formation. (Compare with Halts 1, 2 and 3.)

From the highest hills reached other hills are seen rising northward, in succession, to the horizon.

HALT 330. S. W. ¼, S. E. ¼, S. 13, T. 63-12. Graywackenitic chloritic schist.

The portage southward from Fall lake is about twenty rods east of the mouth of Fall river. It leads over a low ridge by a good path. Fragments of iron schist occur on the portage, and a rod from the trail, on the west, the rock outcrops.

§ 9 GARDEN LAKE.

Garden lake is a straggling body of water lying in the south half of T. 63-11 — mostly in sections 20, 21 and 28. A large portion is rather of the nature of a broad and sluggish river, one branch of which flows out of Farm lake and the other out of White Iron lake, from which it is separated by rapids. The shores afford numerous outcrops of rocks, which are mostly schistose. Graywacke predominates along the southwestern border, as far as the eastern line of section 28, while south of this, sericitic and chloritic schists occur. The lake does not at-

tain the region of the syenite. A long southwestern arm stretching into section 30, reaches the neighborhood of a range of hæmatite which has afforded some specimens of marketable quality, and is believed by explorers to possess much value. At the southern extremity, near White Iron lake, are other indications of iron, which have prompted to some mining operations, and have given origin to the name Silver City.

HALT 145. S. W. ¼, N. E. ¼, S. 20, T. 63-11. Near head of rapids of Fall river. Compact, obscurely bedded graywacke, too hard to scratch, with seams having sericitic surfaces.

Rock 93. Graywacke.

Adjoining is a belt of banded iron schist — the continuation, probably, of that seen on the portage. The same graywacke continues down the rapids a quarter of a mile.

HALT 146. One-eighth mile down the rapids. The graywacke is highly ferruginous and more sericitic. It continues to the eastward bend in the river.

As the suggestion was made that what I have here designated graywacke is really a dike rock, I revisited the locality for more careful examination. The chloritic sericitic schists, as at Halt 140, are almost, if not quite, in contact with the alleged dike. The jaspilitic iron schist, also, can be traced to almost actual contact with it. Whether the dike rock, so called, presents truly the characters of a qualified graywacke or of a proper diabase, which it externally so much resembles, can hardly be ascertained without microscopic study.

HALT 147. N. W. ¼, S. E. ¼, S. 20, T. 63-11. South end of island. Knotted, scarcely bedded, sericitic schist, very hard, having a dike-like bed of fibrous, sericitic felsitic material, striking N. 31°E.— same as at Halt 111. Glacial striæ S. 21° W.

HALT 148. N. E. ¼, S. W. ¼, S. 20, T. 63-13. Chloritic argillitic sericitic schist, very compact, unevenly bedded, knotted and wavy.

HALT 149. S. E. ¼, S. W. ¼, S. 20, T. 63-11. Main land. Boss of solid graywacke, scarcely showing any bedded structure. It contains a chloritic constituent. On the top are some indications of structure striking N. 31° W.— but this direction is to be suspected, as the needle appears to be disturbed. A good deal of ferruginous matter appears in streaks.

Rock 94. Graywacke, compact and hard.

HALT 150. S. W. cor. S. W. ¼, S. 20, T. 63-11. Graywacke with the same diabasic aspect.

HALT 151. N. W. ¼, N. W. ¼, S. 29, T. 63-11. A massive outcrop of graywacke, still externally resembling diabase.

HALT 152. N. W. ¼, N. W. ¼, S. 29, T. 63-11. Graywacke as before.

HALT 153. N. W. ¼, N. W. ¼, S. 29, T. 63-11. Graywacke as before.

HALT 154. N. E. ¼, N. E. ¼, S. 30, T. 63-13. Enormous outcrop of similar graywacke, 40 feet high.

HALT 155. N. W. ¼, N. W. ¼, S. 30, T. 63-11. Same diabase-looking graywacke to the extremity of this arm. Same rock continues on the east side of the arm. From this vicinity made an excursion into the centre of section 30.

HALT 286. Centre of S. 30, T. 63-11. On the iron range. Much flötz of banded iron jaspilite. Some specimens are fair ore; but I saw none here which was really minable. Capt. Julian Bausman, who accompanied me, says this range extends about ten degrees north of east for a distance of half a mile.

Here is a clearing of about one acre, in the midst of a dense forest of slender Norways and tamaracks; and a log cabin stands in the centre. This spot is on the slope of a hill on the border of a swamp.

HALT 287. 50 rods west of last. On a hill the iron jaspilite outcrops rather extensively. I see, however, no fine ore. The black bands in the jaspilite are too hard to scratch.

HALT 288. Twenty rods still further west. Here are fragments of good minable hæmatite. Query: Does the range lie in continuity with the Tower iron range? Or, with the range south of Mud lake?

Rock 136. Banded jaspilite (about thirty bands).

Rock 137. Best iron ore at Halt 288.

HALT 289. N. W. ¼, S. E. ¼, S. 20, T. 63-11. Island. Chloritic argillitic schist.

HALT 156. Centre of N. W. ¼, S. 29. Chloritic sericitic schist, very compact. Like Halt 148.

HALT 157. Near 156. Graywacke rocks.

HALT 157 *bis*. S. E. ¼, S. E. ¼, S. 20, T. 63-11. Chloritic sericitic schist, uneven-bedded, compact.

HALT 158. N. E. ¼, N. E. ¼, S. 29. T. 63-11. Graywacke, a little schistose.

HALT 159. S. W. ¼, S. W. ¼, S. 21, T. 63-11. At point of main land. Graywacke a little greenish.

HALT 160. N. E. ¼, N. W. ¼, S. 28, T. 63-11. Graywacke still, very fine and massive.

Rock 95. Graywacke, very massive.

HALT 161. S. E. ¼, N. W. ¼, S. 28, T. 63-11. Graywacke.

HALT 162. Centre N. E. ¼, S. 28, T. 63-11. Graywacke.

HALT 163. S. E. ¼, N. E. ¼ S. 28, T. 63-11. Chloritic sericitic schist, obviously slaty, but irregular. Strike N. 71° E.

Rock 96. Chloritic sericitic schist.

HALT 164. S. E. ¼, N. E. ¼, S. 28, T. 63-11. Chloritic sericitic schist, very distinctly laminated. Strike N. 71° E. Dip vertical.

Rock 97. Sericitic schist.

HALT 165. S. E. ¼, N. E. ¼, S. 28, T. 61-11. Chloritic schist, medium-bedded, greenish. Dip S., about 85°.

Rock 98. Chloritic schist.

HALT 166. S. E. ¼, N. E. ¼, S. 28, T. 63-11. Chloritic argillite, compact. Strike N. 71° E.

HALT 167. N. W. ¼, S. W. ¼, S. 27, T. 63-11. Exposure on north side, chloritic graywacke; on south side, sericitic argillite, distinctly laminated

HALT 168. N. W. ¼, S. W. ¼, S. 27, T. 63-11. Graywacke.

HALT 169. N. W. ¼, S. W. ¼, S. 27, T. 63-11. Chloritic graywacke, varying to compact chloritic schist. Contains in places a red mineral, like heulandite. Also veins of quartz with much iron.

Rock 99. Chloritic graywacke with red mineral.

HALT 170. N. W. ¼, S. W. ¼, S. 27, T. 63-11. Chloritic graywacke.

HALT 171. N. W. ¼, S. W. ¼, S. 27, T. 63-11. Chloritic graywacke.

HALT 172. S. E. ¼, S. E. ¼, S. 25, T. 63-11. West end of island. Sericitic argillite, very hard and imperfectly bedded. Dip N. 80°.

HALT 173. N. E. ¼, S. E. ¼, S. 27, T. 63-11. Fine hornblendic sericitic schist.

HALT 174. S. E. ¼, S. E. ¼, S. 29, T. 63-11. Silver City. A mining drift excavated about forty feet. The formation is essentially quartz standing in vertical beds, and mostly interbedded with hæmatite and limonite. At the entrance, the drift materials are firmly cemented with limonite apparently filtered out of the formation by percolating water. Next, the quartz beds are much shattered, and mixed with iron. Ten feet in, which

is across the bedding, the formation becomes sericitic schist, somewhat as shown in Fig. 27.

Fig. 27. Stratification at Silver City, Garden Lake.
a, Sand and pebbles, cemented with much limonite.
b, Ferruginous quartz.
c, Ferruginous quartz broken up
d, Quartz.
e, Sericitic quartz.
Vertical face.

Rock 100. Quartzyte from Halt 174.

On the opposite side of the point is another similar drift with similar showing.

HALT 175. N. E. ¼, N. E¼, S. 32, T. 63-11. Foot of rapids from White Iron lake.

HALT 176. Across the rapids from Halt 175. The schists present a towering, columnar aspect, and, on examination, are as follows:

Fig. 28. Columnar schists at Silver City, Garden L.
a, sericitic mica schist, fine.
b, mica schist.
c, mica-hornblende schist.
d, hornblende schist.
e, ferruginous hornblende schist
f, jaspery iron schist.
Vertical cliff.

Here seems to be a transition from sericitic to mica schist, and thence to hornblende schist, and still further to jaspery iron schists. The iron comes in gradually, and by intercalation with the hornblende and silicious schists.

Strike of beds could not be ascertained. The needle, when near the cliffs, presented south end to them; at the distance of fifteen feet, it presented north end to the cliffs.

Rock 101. Sericitic mica schist.

Rock 102. Micaceous hornblende schist — little hornblende.

Rock 103. Hornblendic magnetic schist.

The above series of beds is situated south of the quartzite of Halt 174.

I am led to offer a remark on the mining explorations at Silver City — so-called. The result should have been foreseen. A small expenditure over the surface in uncovering the outcrop of the formation would have revealed the probable nature of the succession of beds, as well as the costly burrowing under the ground, since the drift goes directly across the beds. Another consideration renders the venture an ill-advised one. The tunnel (Fig. 28) penetrates the formation at a place where the beds run out on the shore in both directions, within a short distance, so that if any bed, as *a*, had been found rich in iron, there would not have been enough of it to repay expense of the tunnel.

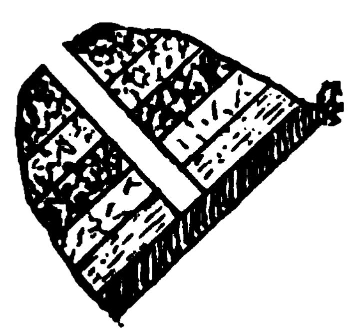

Fig. 29. Relations of Tunnel to stratification at Silver City, Garden Lake, Halt 174. Plan.

HALT 225. S. E. ¼, S. E. ¼, S. 20. T. 63-11. Island. Felsitic, hornblendic schist. Same as No. 6, Halt 224, White Iron lake.

Rock 127. Felsitic hornblendic schist.

Rock 128. Sericitic silicious schist.

It varies to felsitic mica schist and to sericitic silicious schist. Some intruded syenite appears. The schist weathers to a strikingly columnar aspect, forming miniature palisades.

HALT 226. S. E. ¼, S. E. ¼, S. 29, T. 63-11. Interstratifications of knotted, chloritic schist, sericitic silicious schist and silicious schist.

HALT 227. S. E. ¼, S. E. ¼, S. 28, T. 63-11. Very fine, almost aphanitic, mica schist, weathering to a columnar structure.

HALT 228. S. E. ¼, S. E. ¼, S. 28, T. 63-11. Mica schist, silicious and evenly bedded. Good flagstone.

Rock 129. Mica schist.

HALT 229. S. W. ¼, S. W. ¼, S. 27, T. 63-11. Silicious and micaceous iron schists.

HALT 230. A few rods S. of Halt 229. Graywackenitic mica schist. Similar to Halt 227.

HALT 271. Centre of S. W. ¼, S. 27, T. 63-11. Graywackenitic mica schist.

HALT 272. Centre of N. W. ¼, S. 27, T. 63-11. Fine hornblendic mica schist, with indications of iron in the formation.

HALT 273. N. W. ¼, S. W. ¼, S. 27, T. 63-11. Rock at point a mixture of norite, dioryte and hornblendic mica schist. Back a few rods, mostly mica schist with quartz.

HALT 274. S. W. ¼, N. W. ¼, S. 27, T. 63-11. Nodular chloritic schist with signs of iron.

HALT 275. S. W. ¼, N. W. ¼; S. 27, T. 63-11. Compact, bluish, nodular, somewhat chloritic, almost aphanitic paste quite diabasic in external appearance.

HALT 276. N. W. ¼, N. W. ¼, S. 27, T. 63-11. Chloritic, nodular, diabasic-looking rock.

HALT 278. N. E. N. W. ¼, S. 27, T. 63-11. The outcrop, judging from a specimen brought, is a compact chloritic schist.

HALT 277. N. W. ¼, N. W. ¼, S. 27, T. 63-11. Surfaces thinly drift-covered.

HALT 279. N. E. ¼, N. W. ¼, S. 27, T. 63-11. Chlorite schist.

HALT 280. N. E. ¼, N. E. ¼, S. 21, T. 63-11. Chlorite schist.

HALT 281. N. E. ¼, N. E. ¼, S. 21, T. 63-11. Chlorite schist.

HALT 282. N. E. ¼, N. W. ¼, S. 21, T. 63-11. Chlorite schist a little more argillic than the last.

HALT 283. S. E. ¼, S. W. ¼, S. 21, T. 63-11. Porphyry.

Rock 135. Porphyry. This, perhaps, is a variety of so-called porodite.

HALT 284. S. E. ¼, S. W. ¼, S. 21, T. 63-11. Chlorite schist, compact and massive.

HALT 285. N. W. ¼, S. W. ¼, S. 21, T. 63-11. Chlorite rock —a bold and massive exposure.

§ 10. WHITE IRON LAKE.

This considerable lake diverges less from the meridian than Burntside, Long and Fall lakes. Its mean axis bears N. 30° E. Its extreme length, following the slight curvature toward the east, is six and one-half miles, while its length in a straight line is five and two-thirds miles. It has a mean diamater of about three-fourths of a mile, but, like Fall lake, it is narrowed at two places near the middle. The greatest body of the lake is located in T. 62-11, but it extends across the corner of T. 61-11 and into the corner of T. 63-11. Its shores are clothed with the usual timber growths of the region, with a comparative scarcity of pines, and corresponding abundance of spruce, aspen and white birch. Fire has devastated extensive areas on the northeast shore. Rocky outcrops are sufficiently frequent for geological study of the region, but they are almost wanting along the southwestern border, and also along the northeastern. The rocks are almost exclusively syenite and syenitic gneiss, and these are present in many varieties. The shores of the bay lying in section 18 of township 62-11 were not visited, as they were assigned to another explorer.

HALT 177. N. W. ¼, N. E. ¼, S. 32, T. 63-11. Rock bluish-gray very fine, schistose with glistening particles which seem to be micacious. Hornblende (or augite) seams present. It may perhaps be regarded as micaceous graywacke—a graywacke in which mica occurs in an early stage of formation.

Rock 103. Nascent mica schist.

HALT very near last. The fundamental rock is the same as last (nascent mica schist) but here are veins of fine granite, which in places, is without mica, and in places contains a little hydromica or possibly hornblende. Over the surface lie strewn fragments of biotite syenite, which perhaps do not belong here.

Rock 104. Granulite vein.

Rock 105. Biotite syenite.

HALT 179. S. W. ¼, N. W. ¼, S. 32, T. 63-11. Syenite with some biotite. Rock same as 105. I notice fragments of hornblende schist included in it.

Rock 106. Syenite with fragments of hornblende schist.

HALT 180. N. E. ¼, N. E. ¼, S. 30, T. 63-11. Mass of syenite. A 5-inch vein of quartzyte runs through it. The formation covers the whole point and outcrops on both sides.

HALT 181. S. W. ¼, N. W. ¼, S. 31, T. 63-11. Syenite.

Some indications of included portions having a bedded structure.

HALT 182. S. W. ¼, N. E. ¼, S. 31, T. 63-11. Syenitic gneiss with distinct tendency to irregular, rather thin, beds. Hornblende more limited than last, but much free quartz disseminated through the reddish orthoclase.

Rock 107. Syenitic gneiss.

Schistosity N. 20° E. A vein of syenite, with red feldspar running N. 78° W., intersects the formation.

Rock 108. Syenite with vein as above.

HALT 183. S. N. ¼, N. E. ¼, S. 31, T. 63-11. Syenitic gneiss like that of Halt 182, but there is plenty of hornblende with pale red orthoclase.

I find loose pieces with much pale red orthoclase making quite an ornamental stone. Like the vein-stone of Halt 182.

Rock 109. Syenite with much red orthoclase.

HALT 184. Near centre of S. 31, T. 63-11. Syenitic gneiss like Halt 182.

HALT 185. N. E. ¼, S. W. ¼, S. 31, T. 63-11. Syenitic gneiss with red orthoclase, like Rock 109.

HALT 186. N. E. ¼, S. W. ¼, S. 6, T. 62-11. Island. Syenitic gneiss.

HALT 187. N. W. ¼, S. W. ¼, S. 6, T. 62-11. Another island. Muscovite schist, but profoundly intersected by veins of syenite, like that seen for a long distance back. Looks like a transition between the two. But the mica scales are not small.

Rock 110. Muscovite schist.

The same occurs at the south end of the island.

HALT 188. S. W. ¼, S. W. ¼, S. 6, T. 62-11. The north end of this exposure is fundamentally muscovite schist, with crystals of pink orthoclase disseminated through it. In places it approaches gneiss. It is thoroughly cut up with veins of syenite. A few rods south the whole mass is syenite.

Rock 111. Muscovite schist.

HALT 189. S. W. ¼, S. W. ¼, S. 1, T. 62-12. Syenite as before.

HALT 190. S. E. ¼, S. W. ¼, S. 1, T. 62-12. Syenite, but with the pinkish orthoclase are crystals of a glassy feldspar. This syenite forms the whole point.

Rock 112. Syenite with crystals of glassy feldspar.

HALT 191. N. W. ¼, N. W. ¼, S. 12, T. 62-12. Syenite, including fragments of muscovite schist.

HALT 192. N. W. ¼, N. W. ¼, S. 12, T. 62-12. Syenite with red feldspar and coarse grains of quartz.

HALT 193. S. W. ¼, S. W. ¼, S. 12, T. 62-12. The mass of the exposure is syenite or syenitic gneiss with pale orthoclase. It contains a bed or intrusion of syenite, with abundance of red orthoclase. It also incloses masses of schist composed of feldspar, which weathers red, and dark minerals which appear like dark muscovite and some hornblende (or augite), also grains of quartz.

Rock 113. Hornblendic? (augitic) mica schist.

Abundant masses of what I take for augite rock lie about—wholly massive.

Rock 114. Augite rock. (Too soft?)

HALT 194. S. W. ¼, S. W. ¼, S. 12, T. 62-12. Dike of augite 30 feet wide. On the north is syenite with red feldspar. On the south, syenite with a glassy feldspar and abundant hornblende. The latter is a rather fine-grained and handsome rock, but with a very dark tone. The northern syenite is also a handsome rock with pink tone.

Rock 115. Syenite with glassy feldspar.

Rock 116. Augite rock.

The augite is intersected by veins of red syenite, and contains detached masses of it. South of the dark syenite the red reappears.

HALT 195. S. W. ¼, S. W. ¼, S. 12, T. 62-12. Red syenite.

Considerable search was made for a portage out of White Iron lake toward the south and through the stream which comes in from the lake in section 33. There is no thoroughfare to Stuntz lake in this direction. Subsequently I was informed that it is possible to pass the rapids with a light canoe; and that is the course generally pursued.

HALT 196. S. E. ¼, S. W. ¼, S. 24, T. 62-12. Red syenite, as before. It presents a distinct schistosity, striking N. 53° E.

HALT 197. N. E. ¼, N. W. ¼, S. 25, T. 62-12. Red syenite with a vein of fine, compact syenite.

Rock 117. Red syenite with vein of syenite attached.

HALT 198. N. E. ¼, N. W. ¼, S. 25, T. 62-12. Enormous mass of syenite—the feldspar light colored and very coarse. Hornblende also coarse. Intersected by vein of compact syenite.

HALT 199. N. E. ¼, N. W. ¼, S. 25, T. 62-12. Boss of syenite rising 70 feet above the bay. Crystals of feldspar still larger—some being ¾ inch long.

HALT 200. S. E. ¼, S. W. ¼. S. 24, T. 62-12. Syenite, the same as at Halt 199.

HALT 201. S. W. ¼, S. E. ¼, S. 24, T. 62-12. Some porphyritic syenite. It contains a dike of hard, bluish-gray, fine diabase, striking N. 17° E., and forming a sharp junction with the syenite. The dike is eleven feet wide, and both walls of syenite are straight as a rule. It dips east at an angle of 80°.

HALT 202. N. W. ¼, S. W. ¼, S. 24, T. 62-12. Island. Syenite, coarse as before.

HALT 203. N. W. ¼, S. E. ¼, S. 24, T. 62-12. Syenite as before. Contains a vein composed wholly of large orthoclase crystals.

HALT 204. Near centre of section 24. Island. Could not land, but rock looks like gray syenite.

HALT 205. Centre of N. E. ¼, S. 24, T. 63-12. Syenite, but lighter colored.

HALT 206. N. E. corner, S. 24, T. 62-12. Syenite with light feldspar. On the east it becomes fine-grained and gneissic.

HALT 207. S. E. ¼, S. E. ¼, S. 14, T. 62-12. South end of island. Mass of Syenite still coarse, but the feldspar crystals not so conspicuous. The hornblende black and shining.

HALT 208. N. E. ¼, S. E. ¼, S. 13. East side of island. Syenite with pinkish orthoclase and brilliant black hornblende.

HALT 209. S. E. ¼, N. E. ¼, S. 13, T. 63-12. Syenite, coarse grained and fine.

HALT 210. N. E. ¼, S. E. ¼, S. 6, T. 63-12. Near point. Nothing here but sparse drift.

HALT 211. S. W. ¼, S. E. ¼, S. 12, T. 62-12. Syenite gneiss, medium texture, feldspar but slightly pinkish. Contains narrow veins of fine syenite. It embraces a large mass of muscovitic hornblende schist which is profoundly penetrated by veins and detached masses of syenite which are generally less hornblendic than the main gneiss.

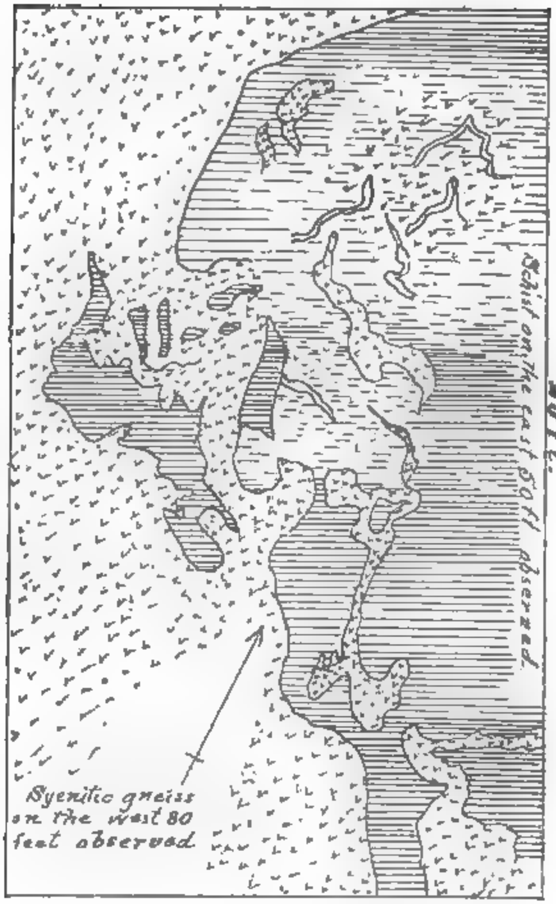

Fig. 80. Syenite inclosing masses of veined schist, Halt 211, White Iron Lake.

The syenitic intrusions continue as far as the schist can be traced.

The syenite on the opposite side embraces innumerable detached fragments of the schist. Portions of the schist are more exclusively muscovitic, others more hornblendic.

Rock 118. Syenite or syenitic gneiss from this locality.

Rock 119. Muscovitic hornblende schist showing junction with syenite.

Proceeding east 20 rods, schist continues, and in a bold expos-

ure, shows the syenite penetrating it extensively and in every direction.

HALT 212. N. W. ¼, S. E. ¼, S. 12, T. 62-12. Syenite.

HALT 213. N. W. ¼, S. E. ¼, S. 12, T. 62-12. Syenite, but the constituents are more blended — the feldspar being reddish, and a somewhat compact mass through which the quartz and hornblende are disseminated. The latter is not in the brilliant black fibrous fragments of the syenite passed over, but dull and somewhat clay-colored. The rock, also, is not homogeneous, but includes pebbles of compact felsitic granulite.

HALT 214. S. E. ¼, N. W. ¼, S. 12, T. 62-12. Syenitic gneiss with the usual bright hornblende and a reddish feldspar.

HALT 215. N. W. ¼, N. E. ¼, S. 7, T. 62-11. Syenite. This has reddish feldspar, and also many large, isolated, distinctly outlined, squarish fragments of quartz. This is like much syenite heretofore seen.

HALT 216. N. E. ¼, N. W. ¼, S. 7, T. 63-11. Syenite like last.

HALT 217. S. E. ¼, S. W. ¼, S. 6 on section line, T. 62-11. Syenite with reddish feldspar, and some disseminate quartz grains.

Rock 120. Syenite from Halt 217.

HALT 218. S. E. ¼, S. W. ¼, S. 6, T. 62-11. Syenite with much reddish feldspar. Embraces masses of syenite of dark color from abundance of hornblende, and of fine texture. Glacial striæ S. 29° W.

HALT 219. Near centre of section 6, T. 62-11. Syenite with red orthoclase and rectangular faces of glassy feldspar.

HALT 220. Near centre of S. 6, T. 62-11. Essentially a reddish syenite; but it incloses several varieties of syenite in lump-like forms. One is a fine-grained variety; another is composed mostly of a dark-greenish hornblende in isolated fragments imbedded in a matrix of pinkish feldspar. Some portions of the main rock are coarse, with large fragments of quartz and feldspar. In some portions the hornblende is bright black, in others dull and greenish.

HALT 221. Near centre S. 6 (east), T. 62-11. Outcrop of dark color, containing biotite, a pale greenish feldspar, some augite in black lamellar crystals, and scattered grains of quartz.

Rock 121. Biotitic quartzose diabase.

This rock extends along the shore about ninety feet in a direction nearly north and south. Toward its southern limits it receives

a little pinkish feldspar and a little quartz, and then more feldspar and more quartz, while the biotite is partly replaced by hornblende, and the rock is a biotitic syenite. Toward the southern limit also, this rock becomes invaded by roundish masses of syenite, some of which is exactly like that noticed at Halts 215 and 217.

Rock 122. Biotitic diabase with accessions of orthoclase and quartz.

Rock 123. Biotitic syenite connected with Rock 122 by transition.

On the north, the formation is limited by a very compact rock in which reddish orthoclase and bluish-gray earthy matters are blended but not thoroughly mixed.

Rocks 124 *and* 125. Rock last mentioned.

HALT 222. One quarter mile N. of centre of S. 5. T. 62-11. Rocky point but not certain outcrop.

HALT 223. N. E. ¼, N. E. ¼, S. 32, T. 62-11. Rock fine, clay-bluish, with glistening points which I think are small muscovite scales. Other constituents are a glassy and greenish feldspar, and a dark mass which I take to be augitic.

Rock 126. Micaceous graywacke schist — a nascent muscovite schist.

Parts of the rock are intersected by a net work of silicious veins exactly as seen in some boulders at Ann Arbor.

Immediately adjoining on the north, the formation is a muscovite schist. Then still further north, within sixteen rods, the formation is a laminated mixture of mica schist, silicious schist and magnetic schist. The needle reverses its direction within distances of six inches. All these schists stand vertically.

HALT 224. N. E. ¼, N. E. ¼, S. 32, T. 63-11. Here mica schist and syenite form a junction, with phenomena similar to those before described. Masses of syenite are included in the mica schist on the north, while at one point, the junction with the mass of syenite is abrupt for the space of five feet. The schist here is hardened with thin leaves of silicious matter banding it, and small lenticular bands of magnetite.

On the syenite side, however, within two feet, the syenite contains fragments of mica schist, hornblende schist, imbedded augite rock with coarse crystals (like that seen at Halt 194), lenticular masses of hornblende gneiss and a peculiar diorite, with the longer axes of the hornblende fragments all turned in one direction; also diorite fragments of finer texture. The diorite fragments are decidedly numerous for a distance.

This syenite passes through the intermediate of coarse quartzose syenite into a compact reddish quartzite which I traced fifteen feet, into the bank.

The needle, over the junction of the mica schist and syenite, is reversed, and does not resume its proper direction in the vicinity. The mica schist, however, stands vertical, and its strike is about forty-three degrees east of north.

We have then, at this intersecting point, the following succession, beginning on the south:

1. Reddish quartzite (passing into)........................... 15 feet
2. Reddish syenite containing many detatched fragments, as described.. 6 feet
3. Mica schist, trending about N. 43° E. and forming a sharp junction, at certain points, with the next, and becoming hornblendic in the vicinity............
4. Reddish syenite again which, as before, incloses masses of mica schist and hornblende schist...... 12 feet
5. Hornblende schist with fibrous structure.................. 6 feet
6. Interlaminations of hornblende- and felsitic schist, growing more and more aphanitic.................... 4 feet
7. Ferruginous sericitic schist, strongly iron colored...... 2 feet
8. Transition between mica- and hornblende schists..... 4 feet
9. Red syenite 190 feet, and passes under the ground.

§ 11. FARM LAKE.

This lake consists of a body having a general oval outline about one mile in average width, and lying mostly on the south border of T. 63-11. With this is connected by a stream, rocky, rapid and not canoeable, a small lake on the boundary line between this and town 62-11. The shores present no important outcrops on the west and south, but several occur on the east; and a small island not on the plats, which I have named Geology island, presents an exhibition of remarkable interest. It lies in the belt of junction of the syenite and schists. This little spot I studied thoroughly, foot by foot, much of the time on my knees, and my notes contain a description as detailed as could be drawn up from field observations. The timber adjacent possesses no special value or interest.

HALT 231. N. W. ¼, N. E. ¼, S. 3, T. 63-11, on town line Porphyritic syenite. Feldspar crystals an inch long, some of them clear as sanidin.

Rock 130. Diabase from dike mentioned below.

Rock 131. Porphyritic syenite. (This rock is marked by mistake "129.")

The syenite is intersected by a dike of diabase seven feet wide, striking east and west, and having a dip N. of 60°. Glacial striæ S. 21° W.

HALT 232. S. W. ¼, S. E. ¼. S. 34, T. 63-11. Porphyritic syenite. Feldspar crystals so large that the weathered surface of the rock resembles a conglomerate. Intersected by beds of finer-grained syenite.

HALT 234. S. E. ¼, S. E. ¼, S. 34, T. 63-11. Coarse syenite—low outcrop.

HALT 235. S. E. ¼, S. E. ¼, S. 34, T. 63-11. Porphyritic syenite in two portions, separated by twenty feet of fine syenite.

HALT 233. S. W. ¼, N. E. ¼, S. 34, T. 63-11. Geology island. I first walked over most parts of this island, and found its geology very complicated. It does not even appear what is the fundamental formation. I find syenite, diabase dikes, mica schist, hornblende schist and silicious schist under various aspects and alternations. In the following description I will begin at the south end, and following the west shore, note what appears.

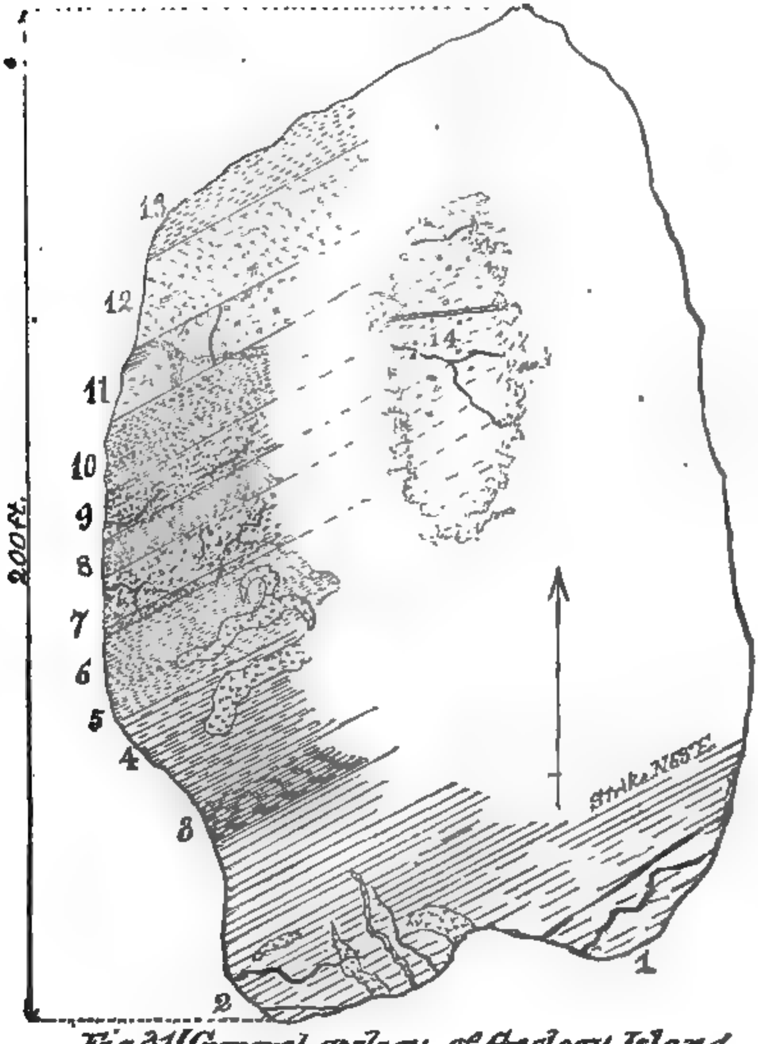

Fig. 31. General geology of Geology Island in Farm Lake, Hall 233.

The numbers show the points referred to in the following description:

1. At the southeastern extremity of the island. Mica schist, striking N. 61° E., and with a S. E. dip of about 75°. It is intersected by many veins of quartzose syenite.

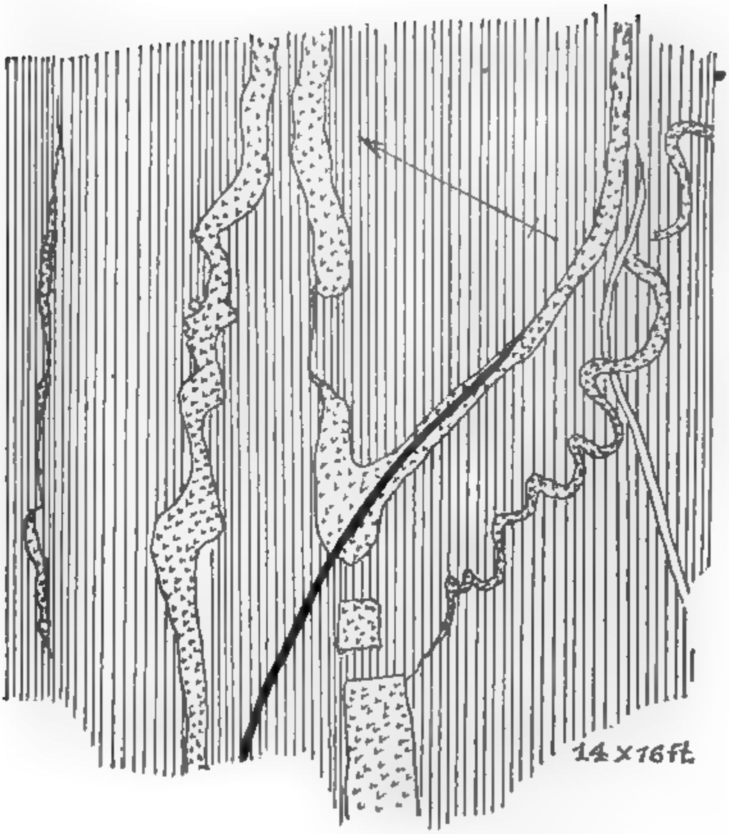

Fig 32. Veins of quartz and quartzose syenite in mica schist, Geology Island. Farm Lake.

2. The mica schist is traceable uninterruptedly to this, t[illegible] most southern point of the island—at frequent intervals inte[illegible]sected by veins of compact syenite. At 2 *a* is a mass of syen[illegible] not in form of a vein.

3. Mica schist more compact, weathering into colum[illegible] forms. About six rods from 2.

[illegible]4. Here a mass of syenite is included in the schist.

[illegible] fine, compact, heavy-bedded biotitic syenite gneiss [illegible] gradation from regular mica schist, both in [illegible] strike and across it. It is intersected by

many masses of reddish granulyte. In the granulyte are also included vein-like forms of quartz — or rather flint. Here also are veins of beautiful syenite, with large crystals of hornblende. An interesting case is shown in figure 33.

Fig. 33, Detailed geology of a point on Geology Island in Farm Lake, Halt 238.

a. Mica schist very fine and compact.

b. Fine, hard, almost vitreous diabasic matter, running with the bedding, but dike-like and not separated by any line from *c*.

c. First comb of a syenite vein in which the ample crystals of hornblende have their longer dimension transverse.

d. Second comb of syenite, in which the hornblende crystals have their longer dimension coincident with the walls of the vein.

e. A comb of granulyte not isolated on either side — very vitreous.

f. Third comb of syenite, in which the hornblende fragments are variously disposed.

g. Second comb of vitreous granulite.

h. Fourth comb of syenite, in which the hornblende is disposed as in *c*.

i. Nearly like *b*.

k. A vein of common syenite.

l. A portion which has become gneissic, but very fine and flinty.

m. A black substance resembling hornblende pulverized and compacted again.

Rock 132. The black substance last mentioned.

n. The portion indicated as red and smoky quartz at this point varies in character from foot to foot. It becomes, perhaps, predominantly, a flinty granulite, with lumps of smoky quartz. The whole mass passes to the water's edge as a regular dike five and one-half inches wide, with a strike N. 68° E. and a dip S. 61°.

7. For two feet beyond this dike the rock is a flinty, fine syenitic gneiss; and this is succeeded by a fine mica schist, in which small grains of quartz are abundantly visible, but besides, is curiously full of rounded lumps of quartz and quartzite about an eighth of an inch long, with transverse diameter less. It contains also, quadrangular crystals of feldspar from one-fourth to one-half inch in length. This mass embraces plenty of granulite intrusions. It extends a distance of thirty feet. It embraces a mass (dike-like) of granulite which in parts contains an abundance of excessively fine scales of mica.

Rock 133. Porphyritic mica schist.

Other irregularly intruded masses are abundant and some of them consist of very fine feldspar and quartz, with very few small scales of mica.

8. Mica schist, fine and well characterized, continuing sixteen feet, and becoming a fine hornblendic mica schist. Then with obscuration of separate grains of hornblendic (or augitic) material it passes into a diabase-like rock.

9. Diabase-like rock—or perhaps a mere graywacke, nineteen feet. It is intersected by many dikes and veins of fine granulyte and fine syenite—though the dark mineral in the latter may be hydromica or viridite.

10. Mica schist, very fine. Mica seems to be muscovite. Rock variable like all the others—passing to a graywacke aspect and then distinctly a muscovitic schist. All profoundly intersected by dikes and veins of greenish granulite. Continues twenty-five feet. Stops at a dike eight inches wide.

11. Mixed mass of hornblende schist and intrusions of granulyte and syenite. Inextricable confusion. Also large inclusions of porphyritic syenite.

12. Syenite, typical, with coarse hornblende, including masses of hornblende schist, 12 feet.

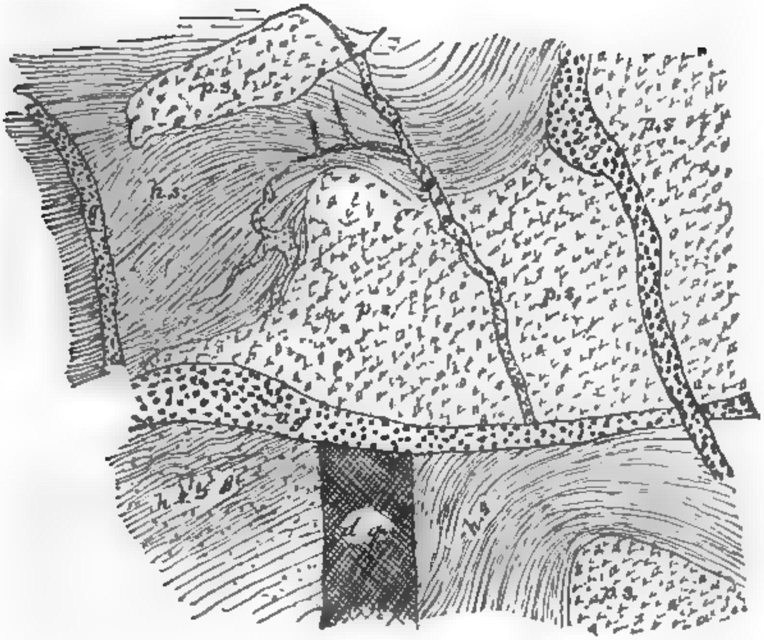

Fig. 34 *Confused mass of schist, syenite granulite and porphyritic syenite on Geology I. Farm Lake.*

g. granulite; h. s. hornblende schist; p. s. phorphyritic senite; q. quartz; v. vitreous; d. dun.

13. Mica schist, intermingled as usual.

14. An exposure which is fundamentally hornblende schist — in places muscovitic — but contains imbedded pebbles of various kinds, giving it in places the appearance of a plum-pudding. These pebbles are mostly rounded, and among them I recognize:

a. Semivitreous granular quartzite.

b. Granular quartzite.

c. Fine syenite.

d. Syenite with scattered large grains of quartz.

e. Smoky quartz.

The exposure is intersected by a two inch dike of beautiful diorite, consisting of hornblende and a pale greenish feldspar. Also by veins of quartz. The conglomeritic character is confined to a distance of about 12 feet.

I have given this little island quite a detailed and patient ex-

amination. Fundamentally it appears to be mica-hornblende schist, but in a state of unstable equilibrium, sometimes turning to mica schist, and at others to hornolende schist.

But the whole mass was formed in immediate proximity to syenites and granulites, and these have been injected into it with infinite diversity of form, direction and volume. The schists and the other rocks are kneaded together, and in places the attrition of the parts produced true conglomeritic constituents. Afterward, when the formation became somewhat consolidated, it was rent by firm-walled fissures which were filled by the various dike materials — granulyte, fine syenite and dioryte.

This little island, not even inditated by the land surveyors, possesses remarkable interest geologically, a wonderful concentration of rock varieties, geological incidents and forms, and well deserves the name of Geology island.

HALT 236. S. E. ¼, N. E. ¼, S. 34, T. 73-11. Porphyritic syenite with dikes of dusky vitreous quartz and coarse granulite — appearing to be a continuation from Geology island.

Fig. 35. Hydromica schist warped around masses of granite, Halt 240, Farm Lake.

HALT 237. S. E. ¼, N. E. ¼, S. 34, T. 63-11. On the shore mica schist 20 feet; then porphyritic syenite 20 feet; then mica schist.

HALT 238. Very near last. Muscovite schist standing vertically.

HALT 239. 20 rods from last. Mica schist passing into graywacke.

HALT 240. Centre of N. W. ¼, S. 34, T. 63-11. A curious exhibition. Greenish hydromica schist warped and twisted in various ways, containing ragged masses of granite and granulyte which, on weathered surfaces of the formation, project from one to six inches above the schist. The longer axes of these fragments are conformable with the schist, even bending where the schist bends, and thus proving that the included masses were plastic at the same time that the schist was plastic, and showing that the whole mixture was, in its various constituent parts, subjected to softening conditions. See figures 35 and 36.

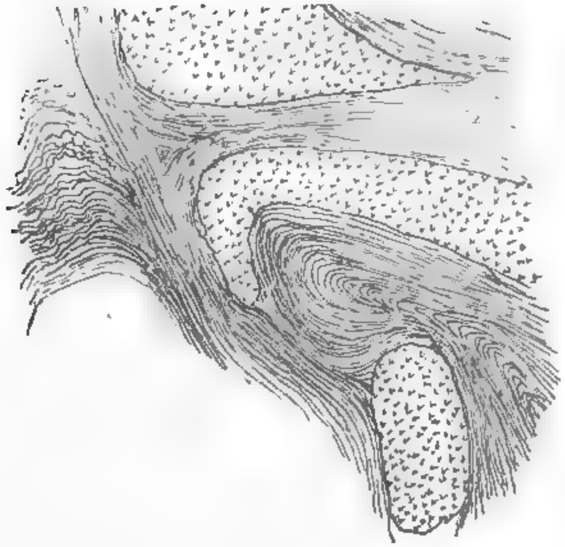

Fig. 36. Hydromica schist and granite both showing indications of plasticity at Halt 240, Farm Lake.

Rock 134. Hydromica schist, some of which shows the bent included granite.

HALT 241. A little north of 240. Very compact biotite hornblende schist, extensively intersected by dikes of fine granite.

HALT 242. Near centre N. E. ¼, S. 34, T. 63-11. Fine com-

pact syenitic gneiss, with some mica — related to the fragments included at Halt 240. Portions of this are twisted together with mica schist, and some of the latter is porphyritic, like that on Geology island.

HALT 243. N. W. ¼, N. E. ¼, S. 34, T. 63-11. Graywacke schist, striking N. 70° E., and dipping N. 88°, interbedded with dike-like beds of quartz, of which I count 19 in the space of 12 feet. In the midst are also large masses of fine hard gneiss.

§ 12. KAWISHIWI RIVER.

This is a winding, irregular stream which drains Birch and other lakes to the eastward, interrupted by frequent rapids, and, in the intervening regions, swelling into little lakes, some of which are worthy of special names. My personal explorations extended up this chain of waters only to the boundary of Range 10. The geology of the vicinity is completely accessible. It occupies a zone of mica schists half or three-fourths of a mile north of the syenite.

HALT 244. S. W. ¼, S. E. ¼, S. 27, T. 63-11. Mica schist, very compact on the north, and shelly on the south.

HALT 245. S. W. ¼, S. E. ¼, S. 27, T. 63-11. Mica schist, very compact, exactly like last.

HALT 246. S. E. ¼, S. E. ¼, S. 27, T. 63-14. Mica schist, like last two Halts.

HALT 247. S. W. ¼, S. E. ¼, S. 27, T. 63-11. Mica schist, but more silicious than last.

HALT 248. N. W. ¼, N. E. ¼, S. 34, T. 63-11. Compact mica schist passing to fine gneiss.

HALT 249. N. E. ¼, N. E. ¼, S. 34, T. 63-11. Mica schist, quite characteristic.

HALT 250. N. E. ¼, N. E. ¼, S. 34, T. 63-11. Mica schist, like last.

HALT 251. N. E. ¼, N. E. ¼, S. 34, T. 63-11. Mica schist, weathered somewhat columnar.

HALT 252. N. W. ¼, N. W. ¼, S. 35, T. 63-11. Compact mica schist.

HALT 253. N. W. ¼, N. W. ¼, S. 35, T. 63-11. Compact mica schist.

HALT 354. N. W. ¼, N. W. ¼, S. 26, T. 63-11. Island and rapids. Compact mica schist. This is the narrows, and the

stream makes a descent over rapids. Here is a portage of about 20 feet across an island. The lake to the east we call Friday lake.

HALT 255. N. W. ¼, N. W. ¼, S. 35, T. 63-11. Near section line. Very compact mica schist in vertical cliff 25 feet high.

HALT 256. S. W. ¼, S. E. ¼, S. 26, T. 63-11. On island. Mica schist quite characteristic. Strike N. 72° E. Dip N. 65°.

HALT 257. S. E. ¼, S. E. ¼, S. 26, T. 62-11. Graywacke schist with a little mica.

HALT 258. S. E. ¼, S. E. ¼, S. 26, T. 63-11. Graywacke schist, some of it with a little hornblende.

HALT 259. S. W. ¼, S. W. ¼, S. 25, T. 63-11. Compact mica schist interbedded with graywacke schist. Present again the multitude of small, ill-defined silicious veins seaming the schist. The graywacke schist contains much feldspar in many distinct grains in undefined outlines.

HALT 260. S. W. ¼, S. W. ¼, S. 25, T. 63-11. Compact mica schist.

HALT 261. S. W. ¼, S. W. ¼, S. 30, T. 63-10. Rapids. Enormous outcrop of syenite with little quartz, a reddish feldspar and large crystalline fragments of hornblende. The formation is intersected by streams of fine syenite, the hornblende crystals in which lie with their longer dimensions paralled with the stream. In the main formation the large fragments of hornblende—some of which are ⅝ of an inch long—lie with their longer dimension in the common direction.

HALT 262. Centre S. E. ¼, S. 26, T. 63-11. Silicious mica schist. Many quartz veins. Strike E. and W. Dip about vertical. Some parts are intensely hard, and the abundance of the feldspar makes it a gneiss. The weathered surface of this looks like a diorite or diabase, the mica being hydromica and very inconspicuous. Perhaps this part, though so hard, may be pronounced one of the varieties of that heteromorphous rock, graywacke.

HALT 263. N. side S. E. ¼, S. 26, T. 63-11. Mica schist mass; but I judge from the attitude that it has been displaced, though certainly not far.

HALT 264. Near centre S. 26, T. 63-11. Mica schist. The quartz is very fine and there are small disseminated grains of feldspar. I suspect the micaceous constituent begins to be sericitic.

HALT 265. N. E. ¼, S. W. ¼, S. 24, T. 63-11. Here the mica-

ceous constituent is less; the feldspathic is more abundant and forming a groundmass, making a rock approaching a felsitic schist, in places. In other places it is more micaceous, but contains imbedded fragments of syenite and quartz veins.

L 7 266. N. E. ¼, S. E. ¼, S. 26, T. 63-11. Island. Same as last, with a further remove from mica schist. Rock presents a massive exterior, but broken specimens show a bedded structure. I see no indications of mica or quartz. It is no more a graywacke than a mica schist. Glacial striae S. 29° W.

HALT 267. S. E. ¼, S. W. ¼, S. 26, T. 63-11. The rock exhibits a recession toward mica schist. It is still hard and presents, as far as I can judge, in the main, a sort of graywacke constitution, with a diabasic aspect; but there are courses of a pale brownish or whitish mica-like mineral which is soft and inelastic, and I therefore designate the rock sericitic graywacke schist.

HALT 268. S. E. ¼, S. W. ¼, S. 26, T. 63-11. Sericitic graywacke schist.

HALT 269. S. W. ¼, S. W. ¼, S. 26, T. 63-11. North side of rapids. Mica schist very compact.

HALT 270. N. E. ¼, N. W. ¼, S. 34, T. 63-11. Mica schist characteristic.

§ 13. BASSWOOD LAKE.

Next to Vermilion lake in extent of surface, Basswood lake presents similar irregularity of outline, with numerous deep bays, but with fewer islands, and accordingly broader expanses of water. It lies on the national boundary, and some of its deep bays protrude into Canadian territory. Its extension along the boundary is about 14 miles. It stretches from the eastern part of T. 65 9 to the western part of T. 65-10. From the boundary in T. 65-10, one of its arms extends southwestward into the centre of T. 64-11. It may be conveniently divided into five great bays or arms, for purposes of nomenclature. Arm I lies chiefly in sections 11, 12, 13 and 14, of T. 64-10. Arm II straggles through the northwestern portion of the same town, covering more or less of sections 5, 6, 7, 8, 9, 17 and 16. Arm III covers sections 3, 4, 9 and 10. Arm IV stretches far southwestward toward Fall lake, covering portions of sections 6, T. 64-10 and 1, 2, 11, 12, 13, 14, 15, 22, 23, T. 64-11. Arm V lies parallel with this on the northwest, and covers portions of sections 36 and 35

in T. 65-11, and of sections 1, 2, 3, 4, 8, 9 and 10 in T. 64-11. In continuation of the axis of Arm IV is that of Arm VI, which penetrates 8 miles beyond the remotest point of the national boundary, near Northeast Cape. The whole length of water, from the northern extremity of Arm IV to the southern extremity of Arm IV, is about 18 miles. On the American side it extends into six different townships.

No attempt will be made to give a physiographic description. The country which it occupies contains many rounded bosses and ranges of hills, some of which attain probably, an elevation of two hundred and fifty feet. The immediate shores along the American side, are generally rocky, and, where not denuded by fire, are covered by a medium-sized growth of pines, poplars, fir, spruce and white birch. Some of the bays abound in wild rice, and this is especially the case with Bays I and II. To these the Indians habitually resort in the season. The lake is frequently swept by winds, and as there are in places expanses of four to ten miles of watery surface, canoe navigation becomes difficult and sometimes perilous.

From Fall lake there are three customary routes of approach to Basswood. Something depends on the direction of the intended voyage after reaching the lake. If one purposes proceeding eastward along the boundary, or southward into Newfound and Moose lakes, it is customary to proceed to the extremity of Fall lake, in S. W. ¼, S. 36, T. 64-11, and pass by three portages to Saturday and Urn lakes, into Arm II. If it is intended to go westward along the boundary, it is customary to pass over the rapids out of Fall lake into Newton lake. These are in the S. W. ¼, S. 3, T. 63-11. Newton lake leads by Pipestone rapids, S. W. ¼, S. 22, T. 64-11, into Arm IV of Basswood lake. From this the journey may be continued westward, or, if the long portages by the first route eastward are to be avoided, an easy portage of half a mile leads from Arm IV, near the centre of S. 6, T. 64-10, to Arm II; and from the northeasterly point of this another easy portage leads to the nearest point of Arm III, whence three miles of canoe-travel lead to Arm I as before.

The description of the geology of Basswood lake, so far as observed by me, will proceed from Fall lake over the portages into Arm I and thence eastward. It will then return to Fall lake and pursue the course down the rapids, through Newton lake and along the east shore of Arm IV, and thence crossing its

mouth to the main shore westward toward Crooked lake. Arm V was not visited by the writer, nor the west shore of Arm IV.

HALT 401. S. W. ¼, N. E. ¼, S. 36, T. 64-11. Saturday lake. Chloritic argillite.

HALT 402. S. W. ¼. N. W. ¼, S. 36, T. 64-11. Compact sericitic schist — parts felsitic.

Rock 174. Compact sericitic schist.

HALT 403. S. W. ¼, N. E. ¼, S. 36, T. 64-11. Sericitic schist. Strike N. 81° E. Dip vertical.

HALT 404. N. E. ¼, N. E. ¼. S. 36, T. 64-11. Bluish-green rock, especially on weathered surfaces; fundamentally a sericitic argillitic chloritic schist; but on the weathered exterior looking somewhat like a conglomerate, in consequence of the presence many masses of different constitution from the matrix, but on partially isolated from it. Some of these masses contain disseminated grains of quartz, and are of fine, light color, but on being broken are greenish, schistose, and little distinguishable from the general matrix. This rock is considerably like that at Halt 318.

Rock 175. Sericitic chloritic argillite.

HALT 405. N. W. ¼, N. W. ¼, S. 31, T. 64-10. Sericitic argillite.

The portage out of Saturday lake starts from a point near the intersection of the town line and north line of S. 31. The portage to Urn lake is dry and plain. The forest is largely white birch, and there are evidences of much Indian occupation.

HALT 406. Centre N. E. ¼, S. 36, T. 63-11. Sericitic schist, argillitic.

HALT 406 *bis*. N. E. ¼, S. W. ¼, S. 30, T. 64-10. Urn lake. North of entrance to lake. Ground completely covered with syenite boulders and fragments.

HALT 407. N. E. ¼, N. E. ¼, S. 30, T. 64-10. Sericitic schist, rather compact.

HALT 408. S. E. ¼, N. E. ¼, S. 30, T. 64-10. Silicious sericitic argillite.

Rock 176. Silicious sericitic argillite.

HALT 409. N. E. ¼, N. E. ¼, S. 30, T. 64-10. Sericitic schist compact, warped, with many veins of granulyte.

HALT 410. Four rods north of Halt 409. A boss of rock which I incline to consider doleryte. It is dark gray, fine grained with glistening points, crystals of calcite and a groundmass of a dark mineral likely to be labradorite. There is a breadth on the shore of twenty-five feet, and I trace it back about thirty feet. In

some parts the calcite is disseminated in the form of amygdules, and on weathered surfaces they are dissolved out.

Rock 177. Doleryte.

Rock 178. Amygdaloid.

HALT 411. N. W. ¼, N. W. ¼, S. 29, T. 65-10. Great mass of fragments of porphyritic granulyte. Rock apparently not far from outcrop. Most of the rock material is feldspar; but there are many disseminated grains of quartz, and many such grains are imbedded in the feldspar individuals, as if the feldspar had grown around them and included them.

Rock 169. Porphyritic granulyte.

In some parts are very fine scales of a whitish mica-like mineral. Close by are great flat masses of greenish sericitic mica schist. Also fragments of coarse muscovite schist.

HALT 412. N. E. ¼, N. W. ¼, S. 29, T. 64-10. Sericitic schist varying to silicious sericitic schist. Strike N. 85°. Dip 75° N.

This lake is very shallow in the eastern part, and the mud is four to eight feet deep. The portage begins at the foot of a little bay filled with aquatic plants, and one can not get the canoe within thirty feet of solid land — and that is a swamp.

HALT 413. N. W. ¼, N. W. ¼, S. 20, T. 64-10. On portage. Very fine dark-colored mica schist, with an obscure hornblendic aspect.

Rock 180. Fine mica schist.

HALT 414. N. W. ¼, N. W. ¼, S. 20, T. 64-10. Basswood lake. Outcrop at end of portage. Rock which seems to be either diabase or norite.

HALT 418. S. E. ¼, S. E. ¼, S. 17, T. 64-10. Rock with hornblende and feldspar, and without quartz — dioryte schist. Some of the shining diallagic crystals can scarcely be distinguished from biotite.

HALT 417. S. E. ¼, S. E. ¼, S. 17, T. 64-10. Hornblende schist, compact and fine, with indications of minute mica scales. The amount of quartz is slight, and portions may be more correctly indicated as dioryte schist — or perhaps hyposyenite schist.

HALT 416. S. W. ¼, S. W. ¼, S. 16, T. 64-10. Hornblende schist very compact and fine, with a slight indication of minute mica scales.

Rock 181. Hornblende schist.

HALT 415. N. W. ¼, N. W. ¼, S. 21, T. 64-10. Essentially

fine mica schist, but different parts are in different conditions. Some is characteristic muscovite schist, compact, with flat lenticules of quartz; other parts are still finer, and one only sees the mica particles under a lens by getting reflections of sunlight. The muscovite seems to be in a *nascent state*.

The whole formation is considerably warped and plicated, but there are no granite veins seen, though the exposure is an acre or so. Strike N. 67° E. Dip N. 75°.

HALT 419. S. E. ¼, S. W. ¼, S. 1¼, T. 64-10. Hornblende and feldspar—probably triclinic. It may be dioryte schist, but very massive. The dark mineral may, however, be augite.

HALT 420. S. E. ½, S. W. ¼, S. 16, T. 63-14. Distinctly schistose, but finer-grained than the last, and approaching the character of a graywacke.

HALT 421. Near centre of S. 16, T. 64-10. Mica schist and granite.

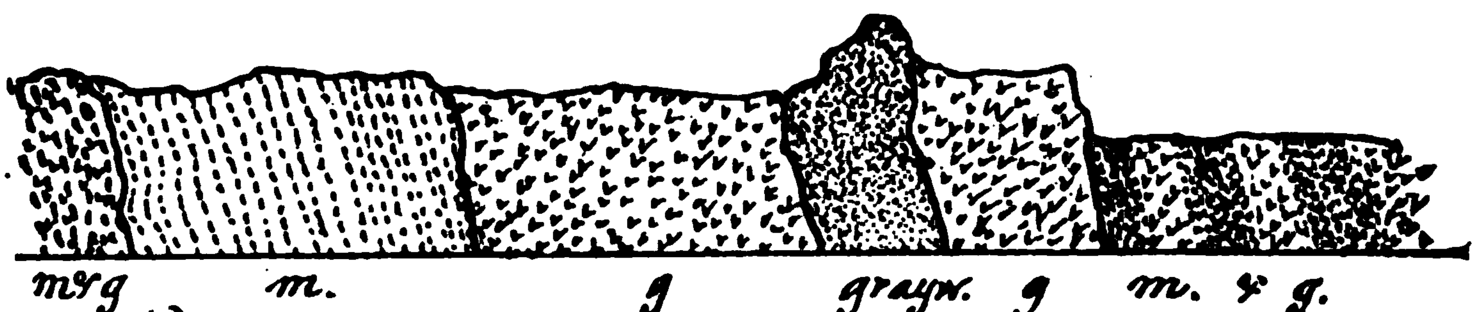

Fig. 37. Alternations of granitoid gneiss and mica schist, Halt 421, Basswood Lake.

The granite is a hydromica-biotite granite. It alternates with the muscovite-biotite schist in thick beds as shown in Fig. 37; and in places is intertwisted in an intricate fashion.

Fig. 38. Intertwisting of granite and mica schist, Halt 421, Basswood Lake.

The granite is not properly in the form of veins or dikes, and the schist is not altered where in contact with the granite, or even embraced in it.

At the beginning of the shore outcrop, the granite and the mica schist are intimately interlaminated for a space of four or five feet.

Back from the shore is a hill seventy-five feet high, composed of syenite and a fine schist, in which the fine dark mineral is probably hornblende, but may be biotite. In other specimens it is certainly biotite.

HALT 422. S. W. ¼, N. E. ¼, S. 16, T. 64-10. Biotite schist and hydromica-biotite granite.

HALT 423. N. E. ¼, N. E. ¼, S. 16, T. 64-10. Syenite.

HALT 424. N. E. ¼, N. E. ¼, S. 16, T. 64-10. Syenite, but with a more hornblendic syenitic gneiss imbedded in fragments.

Rock 182. Syenite—two varieties.

Some of the dark mineral in the included fragments is biotite in part.

HALT 225. N. E. ¼, N. W. ¼, S. 15, T. 64-10. Cliff fifty feet high. Arm I of Basswood lake. Mica schist passing on one hand into graywacke schist and on the other into gneiss.

Rock 183. Graywackenitic mica schist.

Rock 184. Mica schist passing to gneiss.

HALT 426. N. W. ¼, N. W. ¼, S. 15, T. 64-10. Biotitic gneiss.

HALT 427. Centre S. E. ¼, S. 10, T. 64-10. Island. Syenite —some with red orthoclase—some with lumps of a more hornblendic gneiss included.

HALT 428. N. E. ¼, N. E. ¼, S. 10, T. 64-10. Biotite granite.

HALT 429. S. E. ¼, N. E. ¼, S. 11, T. 64-10. Syenite—some with red orthoclase, some with white.

HALT 430. S. W. ¼, S. W. ¼, S. 12, T. 64-10. Syenite, typical; but it incloses some masses of biotite schist, which weather green and fibrous. Portions of the syenite are also replaced by biotite gneiss.

[Observation. This point is thirty-eight miles in a straight line from Tower; and yet we hear with great distinctness, the blasting in the iron mines. The sounds are like those of very heavy thunder from below the horizon.]

HALT 431. S. E. ¼, S. E. ¼, S. 11, T. 64-14. Syenite, typical.

HALT 432. S. W. ¼, N. E. ¼, S. 14, 64-10. Island. Fundamentally a schist which is very fine and so nearly intermediate between biotitic and hornblendic that I can not, with a pocket lens, assign its position. One bed two feet wide, is elegantly banded black, red, green and gray. The black is undoubtedly hornblendic; the red is orthoclasic; the green is epidotic, and the gray is graywackenitic.

Rock 185. Mica schist with colored bands.

Some parts of the formation are distinctly a hornblendic schist. The bedding is distinct. Strike N. 68° E. Dip 30°.

HALT 432 *bis*. N. E. ¼, N. E. ¼, S. 14, T. 64-19. Very fine mica schist, but much like the rock at Halt 432. Strike varies in a rod from N. 68° E. to N. 78° E.

HALT 433. S. E. ¼, N. W. ¼, S. 14, T. 64 10. Argillitic chloritic sericitic schist.

HALT 434. S. W. ¼, S. E. ¼, S. 15, T. 64-10. In the marsh contiguous to a little lake which I call Lost lake.

I reached this lake in the effort to reach Wood lake on the way to Moose lake. We found no portage in that direction. We pushed up a sluggish, winding creek about a mile in a straight line. Retreated with the intention of reaching Moose lake through Carp and Newfound lakes. Wild rice is very abundant in all this vicinity.

HALT 435. S. W. ¼, N. W. ¼, S. 12, T. 64-10. Hornblende rock, but the outcrop is small, and syenite may lie on either hand.

HALT 436. S. W. ¼, N. W. ¼, S. 12, T. 64-10. Island. Syenite, but the exposure is slight, fragments cover the ground.

HALT 437. Centre of S. 12, T. 64-10. Ground strewn with angular fragments of syenite.

HALT 438. N. W. corner N. E. ¼, S. 12, T. 64-10. Syenite. Some of the outcrop along this shore is horizontally bedded in beds two to three inches thick, which separate like strata.

Rock 186. Syenite from Halt 438.

HALT 439. S. E. ¼, S. E. ¼, S. 1, T. 64-19. Syenite, not bedded.

HALT 440. Close by the town line. Syenite horizontally bedded, and looking quite schistose.

All along this shore the syenite proves to be horizontally bedded — in some places the beds only an inch thick.

HALT 441. S. W. ¼, N. W ¼, S. 6, T. 64-9. Bedded syenite giving a slaty impression; but examination shows that the dividing planes are joints. The leaves range from half an inch to two inches in thickness.

Next eastward follow four or five miles of shore line without any outcrop. The beach, however, is covered with angular fragments of syenite.

HALT 445. S. E. ¼, S. E. ¼, S. 33, T. 65-9. The numerous shore fragments are mostly, as heretofore, of syenite, having whitish feldspar, but there are some with masses of hornblende rock, and I preserved one piece in which prisms of hornblende are pretty well preserved.

Rock 187. Syenite with crystalized hornblende.

HALT 443. S. W. ¼, S. E. ¼, S. 34, T. 65-9. Bedded syenite as before. Also massive feldspar and white quartz plentiful. I find fragments consisting of alternate layers of red syenite with little hornblende, and dark syenite with much hornblende and red orthoclase. Both are evidently finely laminated. I find also fragments with hornblende schist in contact with syenite.

Also fragments of very coarse granulite. Also fragments of muscovite schist.

Rock 188. Syenite from Halt 443. Thin scale—not bedded.

Back from the shore a quarter of a mile, the syenite rises in a hill fifty feet high. Here it embraces masses of other sorts of syenite and schists.

Rock 189. Hornblende schist embraced in the syenite last mentioned.

HALT 444. N. W. ¼, S. E. ¼, S. 30, T. 65-9. Island. We find no rocks in place. The beach is lined with very large fragments of the usual syenite. I see also some large slabs of biotite schist.

Walked around the island but found no outcrop, though I am sure the syenite is near. The schist fragments do not appear frequently except on the south side.

HALT 445. N. E. ¼, S. E. ¼, S. 34, T. 65-9. Horizontally bedded syenite.

HALT 446. S. W. ¼, N. E. ¼, S. 25, T. 65-9. Syenite, some with reddish feldspar.

HALT 447. Centre of S. E. ¼, S. 35, T. 65-9. Syenite, but not so massive and homogeneous as heretofore. It is compact, felsitic, with a disposition to bedding with a steep dip N. E. Also some sericitic matter, as if preparing to become a schist.

HALT 448. S. W. ¼, S. E. ¼, S. 39, T. 65-9. Syenite more massive than last, and less felsitic, but mostly less granular than the syenite seen during the day.

HALT 449. S. E. ¼, S. E. ¼, S. 35, T. 65-9. On the beach, alternating beds of gneiss, dioryte schist, granulyte, fine biotite schist wrapped around lumps of common syenite. Strike N. 20° E. Dip 50°.

Further back the formation is somewhat massive syenite, but with a bedded aspect.

HALT 450. N. E. ¼, N. W. ¼, S. 2, T. 64-9. The syenite here is gneissoid.

HALT 451. N. W. ¼, N. W. ¼, S. 2, T. 64-9. Mass very large but detached. It is a fine example of interbedding of schists and gneisses with included masses of syenite.

HALT 452. Near centre, S. 2, T. 64-9. A fine exhibition of the transition from gneiss to schist. The outcrop is fifty feet long and all distinctly bedded. The schists are predominantly hornblendic, weathering green and bluish. Strike N. 80° E. Dip?

Here are alternating beds of the following rocks:

Syenitic gneiss and syenite.

Hornblende schist.
Granulyte schist.
Chloritic schist.
Biotite schist.

The schist beds are in part limited in length — in part continuous across the exposure — warping around lumps of syenite when they are not in bedded form. The interbedding of the syenite and schists is, in places, so intimate that the rock is a visible mixture of the constituents of both, and both kinds of rock lose their identity.

Nothing can be more evident than that the syenite and schists were formed contemporaneously and under the same conditions — whether igneous or sedimentary — but it appears that masses of older syenite existed, from which fragments were separated to mingle with the forming bedded terrane. But the older syenite was not necessarily quite solid; it may have been aqueo-igneously plastic.

Transitions of this character between the syenite and the schists are little favorable to the theory that they belong to two different Great Systems.

Rock 190. Specimens illustrating the transition from syenite to schists.

The "chloritic schist" is mostly confined to thin partings. The biotite is mostly mixed with hornblende.

This locality is near the eastern limit of Basswood lake. The course of a few following observations is westward, touching some of the northern shores of the same bays.

HALT 630. N. E. ¼, N. E. ¼, S. 2, T. 64-9. Island. Syenite with pink feldspar.

HALT 885. Island north of point in S. 35, T. 65-9. Syenite.

HALT 886. One-third of a mile west of Halt 885. Syenite. This is a good medium-grain, typical syenite, with the three constituents clearly defined and in about equal proportions. Very suitable for constructions.

HALT 887. By three logs cabins, on a large island lying in Section 2, T. 64-10. Syenitic gneiss and schist interbedded The islands and main shore northwest of this are occupied by syenitic gneiss. Diorite occurs in the northeast corner of Section 4, T. 64-10.

HALT 888. N. W. ¼, S. 4, T. 64-10. At entrance to terminal bay of Arm 4, Basswood lake. Syenitic gneiss and mica schist. The opposite shore of this bay is syenitic gneiss..

A portage leads from near the head of this bay northwest to a bay belonging to Arm II. It is very wet for a few rods, then elevated and dry for a third of a mile.

HALT 889. Near centre of S. 5, T. 64-10. Syenitic gneiss and mica schist interbedded.

An island in the northern protuberance of Arm II is of mica schist, and the same occurs on the point of main land immediately south of it; while the main land northwest is dioritic.

The course of the observations now returns to the outlet of Fall lake at the rapids.

HALT 631. N. W. ¼, N. W. ¼, S. 3, T. 63-11. At the rapids. A bank of decomposing sericitic schist, appearing like mere drift.

The rapids convey enough water to permit a canoe to be guided down without portaging, but the operation is difficult at time of low water.

HALT 632. S. W. ¼, N. W. ¼, S. 34, T. 64-11. Newton lake. Very compact chloritic schist on the beach; adjoining, further back, chloritic schist weathering green, and with veins of quartz; and still further back, on the hillside, a conglomerate looking chloritic schist containing many veins and lumps of quartz, and detached, angular, elongated fragments of the same sort of rock, but a little harder. The rock, accordingly, weathers very rough. Strike obscure—seems to be N. 12° E. Dip about vertical.

HALT 633. Centre N. W. ¼, S. 34, T. 64-11. On the shore is a rugged mass, distinctly schistose but composed largely of a mineral of a dull green color, and lamellar crystallization resembling what I called augite on White Iron lake, but here more probably, massive chlorite. Strike N. 6° W?

Rock 252. Chlorite rock.

Back of this is compact, fine-grained, even aphanitic, sericite schist, quite silicious.

Rock 253. Aphanitic, silicious sericitic schist.

Some parts of this contain many imbedded specks which appear to be feldspathic.

Rock 254. Aphanitic sericitic schist with feldspathic specks.

The narrows in this lake are not rapids. Only a few bolders obstruct the passage.

HALT 634. N. W. ¼, N. E. ¼, S. 34, T. 64-11. Sericitic schist parts of which contain innumerable thin laminæ of reddish feldspar. Strike N. and S. Dip vertical. In some parts the feldspar is in the form of numerous small lenticules. In some places thin layers of quartz are interbedded.

Rock 255. Sericitic schist, Halt 634.

HALT 635. S. W. $\frac{1}{4}$, S. 26, T. 64-11. Compact sericitic schist, almost aphanitic, breaking into huge timber-like and plank-like pieces with striated surfaces suggesting the grain of wood. Strike N. 86° E. (?) Dip 60° N.

Some portions are filled with minute whitish shining scales, as if a mica schist were emerging into visibility.

Rock 256. Sericitic schist with minute shining scales.

These scales appear especially on the weathered surface. This part of the rock is silicious.

The formation contains masses of quartz and of granulyte.

HALT 636. N. E. $\frac{1}{4}$, S. 27, T. 64-11. Aphanitic, thin laminated sericitic schist. Strike N. 70° E. Dip N. 60°.

HALT 637. N. E. cor. S. 27, T. 64-11. Chloritic schist, thin laminated, easily crumbling into small scales. Weathers rough, with perforations. Strike N. 86° W. Dip vertical. Contains masses of quartz crystals and of feldspar, and in places is intimately interlaminated with them.

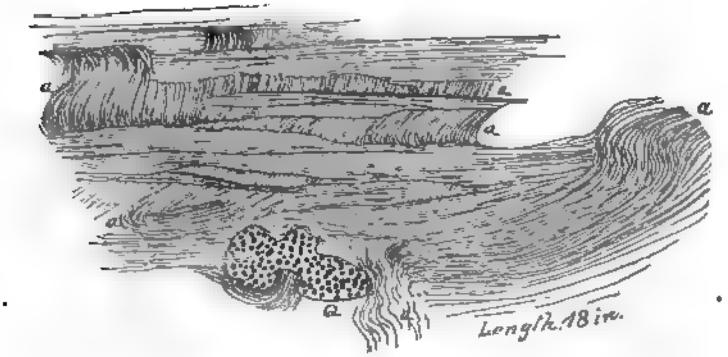

Fig. 39. Relations of chloritic schist and quartz masses at Halt 637, Newton Lake.
Q, quartz. a, a, a, chloritic schist warped and in places nearly faulted.

a a a, chloritic schist, warped.

Portions are considerably plicated, and the plications are sometimes almost faulted, as at *a a a*.

HALT 638. S. E. cor. S. 22, T. 64-11. Chloritic, sericitic, argillitic schist, with minute shining scales, as if about to become mica schist. Strike N. 82° E. Dip 82°.

Rock 257. Nascent mica schist.

At the northern extremity of Newton lake is a fine waterfall. The stream is 10 rods wide and the descent about 8 feet, in a broken plunge. It descends into a gorge bounded on the west by a precipitous rock wall, and on the east by a steep, earth-covered cliff, in which the "pipestone" is contained which gives name to these falls. These beds are exposed at the head of the falls, on the east side. They are not much valued for pipestone —being too silicious. They are intercalated in silicious schists and possess a bluish color. The main portage enters at the most northern point which a canoe can reach, and is not over 10 rods long, coming out at the foot of the falls.

HALT 639. At foot of falls. Outliers of the formation consist mostly of quartz; but this is in masses wrapped in chloritic schist, indicating that the replacing process seen begun at Halt 637 (see figure) has here been carried to extreme.

HALT 640. At expansion of the gorge on the east side. The bluff here is a mixture and alternation of syenitic gneiss, hornblende schist and chloritic schist.

Rock 258. Syenitic gneiss as above.

HALT 641. Foot of falls west side. Escarpment thirty feet high. Syenitic gneiss as at Halt 640. It is distinctly bedded in conformity with the schists of the region. It contains a chlorite constituent, and is interstratified with portions approaching chlorite schist. All the joints are lined with a film of chloritic schist.

Rock 259. Syenitic gneiss as above.

Twenty feet further down, the gneiss is succeeded by fine compact graywacke schist containing in places, mica scales.

Rock 260. Graywacke schist as above.

But between this and the gneiss is an intermediate condition in which the schistose and gneissic constituents appear commingled in a fine magma, but not homogeneously mixed, since the laminar coloration reveals the contrasts among them.

Rock 261. Magma as above.

The graywacke mica schist described has a strike N. 65° E. and dip N. 78°.

Rock 262. Small specimen showing 261 in contact with the gneiss.

Back from the shore thirty feet and across the strike of the formation and back of the mass of gneiss (Rock 259) occurs an intercalation of micaceous hornblende schist as below.

Rock 263. Micaceous hornblende schist.

HALT 642. S. W. ¼, N. W. ¼, S. 22, T. 64-11. Syenitic gneiss and chlorite as at Halt 640.

HALT 643. S. W. ¼, N. W. ¼, S. 42, T. 64-11. Gneiss containing considerable chlorite and weathering green. The longer axes of the dark minerals all lie in one direction. The formation is intersected by quartz veins and granulyte veins — also contains irregular lumps of granulyte. Strike N 80° W.

HALT 644. S. E. ¼, S. 22, T. 64-11. We have here again micaceous hornblende schist on the north side, and syenitic gneiss on the south. The contact where seen is abrupt.

Rock 264. Micaceous hornblende schist as above.

HALT 645. S. E. ¼, S. W. ¼, S. 15, T. 64-11. Island. Chiefly syenitic gneiss, but it contains beds of hornblende schist. Also veins of quartz and of epidote.

Rock 265. Samples in which the constituents of syenite or hyposyenite are mixed with an equivocal dark mineral which is a condition of the hornblende (chlorite) found in included beds.

Examining further these curious lithological conditions, I find the main rock to contain little or no quartz and no hornblende. It is essentially a mixture of feldspar and chlorite, and might be called a chlorite hyposyenite in a gneissic state, but it should have a distinct name.

It is impossible to break the rock into standard specimen form, but I preserved twenty-five or more specimens in the best shape possible.

Postscript. A rock composed essentially of chlorite and feldspar, with a variable but subordinate quantity of quartz, is widely distributed along the national boundary. I have no doubt that it has been in a rough way designated as syenite, or even as granite, since it is simply granitic in general aspect. It is not, however, a granular rock, and appears to be largely composed of matter of the second order of consolidation (Fouqué and Michel-Lévy.) It has been fully established, however, that the chloritic constituent in crystalline rocks, is very frequently a transformation product from augite or amphibole. This formation may, therefore, have once been a diabase or diorite, and this opinion is favored by the contiguous and included beds of hornblende schist. It may prove that the feldspathic constituent is monoclinic, and thus the formation may originally have been a hyposyenite as at first suggested. But it is none of these now. Chlorite exists in place of amphibole or augite. We can

not designate a rock mineralogically for what it has been, but is no more. If composed of chlorite and feldspar we must name it with regard to its actual constitution.

Epidiorite, according to Gümbel, is a greenish rock containing amphibole, plagioclase and a subordinate quantity of augite, together with a chloritic constituent and some titanic iron. The rock in question does not sensibly deviate to a very material extent from epidiorite—even to the titanic iron, which, if not noticed at this Halt, was abundant enough in the immediate vicinity. Still the predominance of amphibole in true epidiorite is a divergence of some moment; and, as a similar rock frequently contains quartz as will be seen, it may well be doubted whether it belongs to the same group of geological causes. I still think, therefore, that precision of language requires for it a special designation.

When the rock contains quartz, it approaches the constitution of protogine, and such a rock when schistose, is the "chlorite gneiss" of Rath. The rock in question here is at least in places obscurely bedded and might perhaps be designated chlorite-gneiss.

The observations show a wide distribution of rocks having a general constitution as follows:

Feldspar, chlorite. Subordinately hornblende, quartz, menaccanite, etc. (Chlorite hyposyenite or epidiorite).

Feldspar, chlorite, quartz. Subordinately hornblende, biotite, etc. (Chlorite granite. When schistose, chlorite gneiss.)

HALT 646. S. 15, T. 64.11. Rock with the chloritic constituent reduced to a minimum. What remains is chiefly feldspar in which I detect occasional grains of quartz.

Rock 266. Chlorite granite—specimen of above.

Another part of the outcrop consists of fine hornblende-like schist, but very heavy and not characteristically hornblende. I suspect it consists of hornblende, menaccanite and a feldspar.

Rock 267. Menaccanitic hornblende schist.

The formation contains large lumps of coarse granulite and many quartz veins. The bedding is much plicated, but there is not enough uncovered to ascertain the strike. In another place the rock has a fine gneissic aspect, with strike N. 30° E. and dip N. 82°.

HALT 647. N. W. ¼, S. 23, T. 64-11. Rock fine crystalline dark-greenish schist. It at first glance appears like a hornblende schist or hornblende rock. Some surfaces appear to con-

tain biotite. I see no quartz. There is a small amount of a feldspathic matrix. The dark-greenish mineral I suspect to be essentially chlorite or augite.

Rock 268. Rock as above.

Immediately contiguous is a gneissoid rock in which the dark mineral is chlorite.

Rock 269. Chlorite gneiss.

HALT 648. N. E. ¼, N. W. ¼, S. 23, T. 64-11. Syenitic gneiss with much chlorite.

HALT 649. S. E. ¼, S. W. ¼, S. 64-11. Syenite gneiss with chlorite.

Rock 270. Syenitic gneiss with chlorite.

HALT 650. Near centre S. 14, T. 64-11. Island. Rock having the appearance of a conglomerate. But it is essentially a syenitic chloritic gneiss with the dark mineral represented mostly by a rusty powder, so that the formation is in a crumbling state.

This very probably represents the final transformation of a rock primitively amphibolic or augitic.

HALT 651. N. E. ¼, S. 14, T. 64-11. Disintegrating, syenitic gneiss, like last. Like the last it shows a rudely bedded structure in horizontal planes.

HALT 652. Near centre S. 14, T. 64-11. A schist which is perhaps a graywacke, though it much resembles the rock at Halt 647. It has more of the feldspathic groundmass. This holds thin scales which impart a waxy translucency. In some parts of the outcrop the feldspar is accumulated in small granules. In other parts the feldspar is wanting, and the dark green mineral occurs in crowded folia which are inelastic, and some of them are silvery in lustre. I take all these for chlorite.

Rock 271. Chlorite schist last mentioned.

In immediate connection with these rocks I find regular chlorite gneiss, in which are included masses of the graywacke schist in which the feldspar exists in distinct granules.

HALT 653. S. W. ¼, S. 12, T. 64-11. Rotten chloro-syenitic gneiss.

HALT 654. S. 12, T. 64-11. Syenitic gneiss with chlorite, compact.

Rock 272. Chloro-syenitic gneiss.

HALT 655. N. W. ¼, S. W. ¼, S. 12, T. 64-11. Very fine fibrous micaceous hornblende schist, of dark color. If still finer it would be argillitic.

Rock 273. Micaceo-hornblende schist.

This is interbedded with various other forms of bedded rocks: chlorite rock, graywacke schist, and chloro-syenitic gneiss. Strike N. 50° E. Dip 70°. I note one chlorite bed 8 or 10 feet thick, and when broken it appears as if kneaded together with gravel, but the nature of the gravel can not be seen. The specific gravity is high.

Rock 274. Gravelly chlorite rock as above.

Many quartz and granulitic veins traverse the formation—many finely interlaminated layers of quartz.

HALT 656. S. E. ¼, N. W. ¼, S. 12, T. 64-11. Mica schist, quite characteristic, very fine, thin laminated, in part slaty and in part compact, much intersected by quartz veins, and with many included laminæ and lumps of quartz. Strike N. 43° E. Dip S. 80°.

Rock 275. Mica schist as above.

HALT 657. S. E. ¼, S. W. ¼, S. 1, T. 64-11. Syenite with red orthoclase, but the dark mineral is chloritic. Contains also a glassy feldspar in small quantity.

HALT 658. Sec. 1, T. 64-11. Syenite with red feldspar.

HALT 890. Near centre S. 6, T. 64-10. Hornblende schist penetrated by syenite.

HALT 659. N. W. ¼, S. 6, T. 64-10. Mica schist fine, thin-bedded. Bedding much warped. Strike N. 40° E. Dip 75° S.

HALT 660. N. W. ¼, S. 6, T. 64-10. Chlorite schist with granules, like that interbedded at Halt 655; but here the granules are decaying and the weathered surface is covered with pits.

HALT 661. N. W. ¼, S. 6, T. 64-10. Entrance to straits. Syenite with white feldspar and a dark mineral fringed with chloritic green.

HALT 662. N. E. ¼, S. 6, T. 64-10. Compact syenite.

HALT 663. N. E. ¼, S. 6, T. 64-10. Syenite—usually so-called, but the dark mineral is chloritic.

HALT 664. N. E. ¼, S. 6, T. 64-10. Syenite with red feldspar.

HALT 665. S. W. ¼, S. 31, T. 65-10. Dioryte. Large fibrous crystals of hornblende imbedded in a matrix consisting of small grains of white and pale green feldspar.

Rock 276. Dioryte as above.

HALT 666. S. W. ¼, S. 31. T. 65-10. Syenitic gneiss of various aspect.

HALT 667. S. W. ¼, S. 31, T. 65-10. Syenitic gneiss, very distinctly bedded, including great masses of coarse chloritic syenite gneiss.

I followed a continuous outcrop around the cape for twenty or thirty rods, interested by appearances of greatly diminished dip. The formation embraces quite a succession of rocks: syenitic gneiss, chloritic gneiss, mica schist, hornblende schist, dioryte schist, and these in various states all warped in common or singly, and much disturbed by numerous veins of granulyte and quartz which intersect the other rocks in all directions.

The dip is exposed quite extensively, and varies from 10° to 40° north of east to nearly east.

HALT 668. N. E. ¼, S. E. ¼, S. 36, T. 65-11. Gneiss of various qualities, interbedded with diorite schist, and crossed by many veins of coarse granulite and of quartz. Strike N. 88° W. Dip N. 85°.

Some fifteen rods south, the strike is N. 88° E.

The dark mineral in this formation is mostly a bright, sharply outlined hornblende.

HALT 669. N. W. ¼, S. W. ¼, S. 31, T. 65-10. Syenite with red feldspar — considerably broken up and irregular, but an enormous outcrop. The same continues along this shore to the narrows.

HALT 670. At the narrows. Syenitic gneiss very massive and compact, with an abundance of red feldspar, causing the outcrop to appear distinctly red at a distance. That this is gneiss is shown by the position of the elongated dark mineral, by the intercalation of beds of hornblende schist, and by the general lack of uniformity in the aspects of the outcrop.

HALT 671. S. E. ¼, S. E. ¼, S. 30, T. 65-10. Syenitic gneiss, medium texture with red feldspar.

HALT 672. N. E. ¼, S. E. ¼, S. 3, T. 65-10. Syenitic gneiss. Texture varying from coarse to fine — some large orthoclase crystals. The bedding planes are distinct and in places somewhat crowded together. Strike N. 60° E. Dip 85° N. W.

HALT 673. N. W. ¼, S. 29, T. 65-10. Syenitic gneiss with red feldspar, some portions containing very little hornblende. There are intercalations of hornblende schist, and even of muscovitic hornblende schist. Some beds contain iron and appear menaccanitic, with high specific gravity. Strike N. 60° E. Dip vertical.

Rock 277. Menaccanitic schist.

HALT 674. N. E. ¼, N. W. ¼, S. 29, T. 65-10. Syenitic gneiss, very distinctly bedded, with many intercalations of mica-hornblende schist. Strike N. 50° E. Dip vertical. The gneissic portions are also introduced in large masses around which the schists are wrapped.

HALT 675. S. W. ¼, S. W. ¼, S. 2, T. 65-10. Syenitic gneiss occurring in great sheets by which beds of schist are both intersected and inclosed.

HALT 676. N. W. ¼, S. W. ¼, S. 20, T. 65-10. Syenitic gneiss, fine, solid, massive and somewhat homogeneous. Strike S. 40° E. Dip vertical.

HALT 677. Here are the rapids or falls which mark the end of Basswood lake and the boundary. If I have my position correctly on the plat, the point is a mile east of the narrowest portion of the water indicated. The stream descends about 25 feet in the distance of 8 rods, and presents an interesting scene, even at this low stage of water.

The rock here is granitic and rather coarse. The quartz and feldspar exist in equal quantities. The dark mineral is much less in quantity, and is ill-defined. Occasionally it is mica—apparently biotite; some portions have a chloritic look, and other portions are apparently hornblende. The general structure of the formation is granitoid rather than gneissoid. Certainly it is not schistic, and it would not be possible to determine any strike.

HALT 730. S. W. cor. S. 29, T. 65-10. Basswood lake. Syenite gneiss and biotite schist. The gneiss contains little quartz, the schist a little hornblende and but little quartz. The mass is mostly gneiss. The schist occurs as fragments, not continuous as strata.

HALT 731. S. W. ¼, S. 22, T. 65-10. West side of the great promontory, in the narrows of Arm V. Rock chloritic and sericitic—some parts in thin splinters with a waxy translucence—fracture very uneven, weathering rough and somewhat craggy. Strike N. 30° E. Dip vertical.

Rock 294. Chloritic sericitic schist as above.

§ 14. CROOKED LAKE.

From Basswood this is reached through an irregular river along the boundary, broken by a succession of falls and rapids. The length of this connecting stream is about 11 miles, and the

length of Crooked lake about 13 miles. The shores of these waters are generally clothed with a scant forest containing Norway pines of moderate growth, some white pines, and many aspens and birches. A small species of oak is not unknown. Many shores however are lined by massive outcrops of crystalline rocks essentially syenitic and many bald knobs of syenite are seen rising in the background, sometimes glowing with a ruddy hue imparted by an abundance of red feldspar which assumes its striking color only after weathering.

HALT 678. N. E. ¼, N. E. ¼, S. 19, T. 65-10. Rapids beyond the falls out of Basswood lake. Biotite gneiss very well defined. Contains beds in which the materials are very fine and the biotite abundant, the rock approaching biotite schist, though the quartz is inconspicuous. Strike N. 65° E. Dip vertical.

Some portions are quite coarse and almost a pure granulyte.

HALT 679. Lower end of rapids, about 20 rods from Halt 678. The rock is a well-defined syenitic gneiss with a little biotite. It tends to separate into horizontal beds.

On an island opposite is the arrangement of rock structure shown in the following figure:

Fig. 40. Discordant bedding at Halt 679, on the boundary between Basswood and Crooked Lakes.

a, discordant bedding. The black lines and shading represent hornblende. The principal mass is gneissic. The hornblende is everywhere strewn in streaks. At h. h h. the hornblende is excessive in proportion.

The black lines and shading represent hornblende. The principal mass is gneissic. The hornblende is everywhere strewn in streaks. At *h h* the hornblende is excessive in proportion.

The diagram covers 3 feet by 4 feet.

The whole descent of these rapids is about 25 feet in the space of 20 rods. But there is an island here, and a portion of the water descends by another rapid on the American side.

In a quarter of a mile the stream rapidly narrows and turns suddenly northward through a gorge about 30 or 40 feet wide. The water is swift and some boulders are seen in the bottom, but we guided the canoe safely, and on the return were able to paddle up the current.

Next, the stream turns suddenly westward, and in a quarter of a mile we come to Rapids No. 2 around which we make a port age on the American side.

HALT 680. N. W. ¼, S. 19, T. 65-10. Upper end of Rapids No. 2. Syenitic gneiss distinctly bedded. Strike N. 60° E. Dip vertical.

These rapids are a quarter of a mile long, and the total descent I would estimate at 59 feet.

HALT 681. N. W. ¼, S. 19, T. 65-11. Lower end of Rapids No. 2. Coarse biotite gneiss, with little mica. Strike N. 50° E. Dip vertical. Parts of it weathering very rough.

HALT 682. N. E. ¼, N. E. ¼, S. 24, T. 65-11. At rapids No. 3. A canoe will pass over these rapids. The rock exposure is biotite gneiss. Some parts, however, are very coarse and contain muscovite.

HALT 683. N. E. ¼, S. 24. T. 65-11. At rapids No. 4. These rapids are in two steps extending a quarter of a mile and descending about 10 feet in all. Rock distinctly gneissic, but with alternating beds of schist throughout. The dark mineral in the gneissic and the schistic beds is probably muscovite, since it is in part dark bronzy, though portions are nearly black. Strike N. 60° E. Dip vertical. The following view was taken while standing on shore:

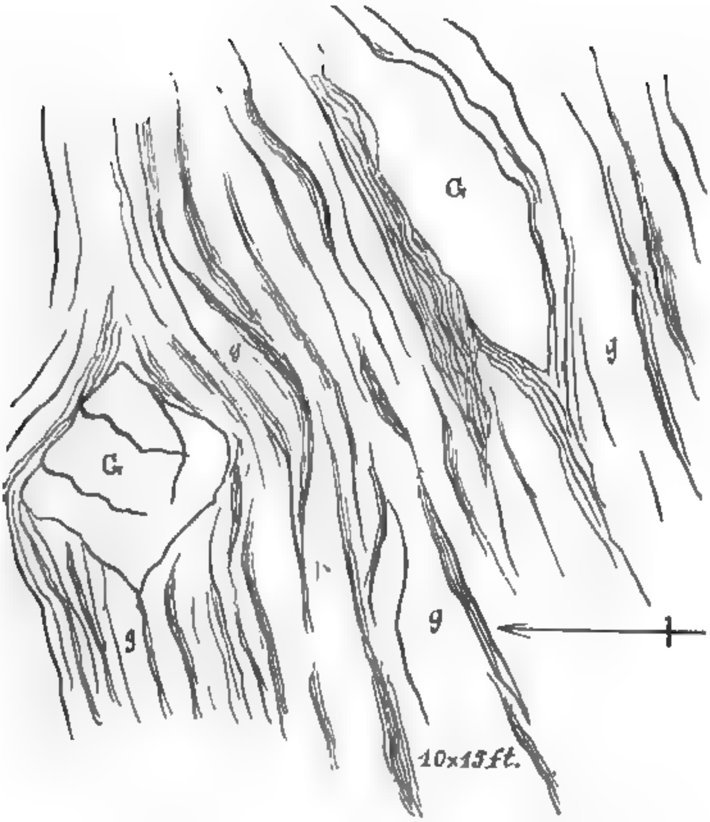

Fig. 41. View under the water at Rapids No 4, Halt 683, on the boundary below Basswood L.
The dark bands represent schists, the light spaces between are gneiss, g, g, g. Detached included masses are seen at G, G. —one with veins.

The dark bands represent schists, the light spaces between are gneiss.

Most of the rock, however, in this vicinity, for 30 rods, I find to be either a coarse granulyte with an excess of red orthoclase, or a syenitic gneiss with a little obscure hornblende.

HALT 684. N. W. ¼, S. E. ¼, S. 24, T. 65-11. Rapids No. 5. Gneiss with the dark mineral obscure, but interbedded with biotite gneiss.

HALT 685. N. E. ¼, N. W. ¼, S. 24, T. 65-11. Massive gneiss with very little of a dark mineral.

HALT 686. Centre S.W. ¼, S. 13, T. 65-11. Syenitic gneiss with very little and very obscure hornblende. Interbedded with beds of biotite schist 15 feet wide and under. These, however, as I ascertain, are not continuous strata, but apparently enormous chunks of a formation solidified and broken into fragments and plunged into a mass of plastic gneiss material.

HALT 687. N. W. ¼, S. 13, T. 65-11. Syenitic gneiss with much red feldspar. Enormous outcrops here and on all sides. The rock is very massive and the bedding planes are only occasionally revealed. The dark mineral exists in small quantity and is only obscurely hornblende. Strike N. 40° E. Main system of joints east and west.

HALT 688. On the line between sections 13 and 14, T. 65-11. Rapids No. 6. Here are the most furious rapids yet seen. The descent I estimate at 25 feet and the length of the rapids at a quarter of a mile. The stream is narrowed in places to 20 feet. A high bluff rises on the south and a ridge on the north. The pressure of the ice gorge here must be enormous. Accordingly, something like a lateral moraine borders the stream on the north side. It consists of rounded granitic debris appearing like boulders, many of them 4 to 6 feet in diameter piled in a rude wall 6 to 12 feet high.

The rock here is a syenite composed mostly of quartz and red feldspar; and part also a granite composed of quartz, white feldspar and a lustrous silvery mica. As I do not discover any bedding planes (though my opportunity for observation is limited) I set this formation down as syenite and granite. But it is my profound conviction that its history has differed little from that of the recognized gneisses; and with adequate opportunity for investigation, I could probably discover bedding planes.

Rock 278. Muscovite granite (silvery mica).

HALT 689. N. E. ¼, S. E. ¼, S. 14, T. 65-11. Syenitic gneiss distinctly bedded.

HALT 690. N. W. ¼, S. E. ¼, S. 14, T. 65-11. Gneiss, but thoroughly interbedded and kneaded with mica schist and hornblende schist. Strike N. 55° E.

HALT 691. S. W. ¼, S. W. ¼, S. 14, T. 65-11. Rapids No. 7. A mass of gneiss remarkably belted with sundry grades of coarseness and constituent proportions, and sundry schists. The schists in places occupy about half the mass. On the whole, however, I think one-sixth of the mass would be an approximate statement. The warping and wrapping are very remarkable—

both of the gneiss around the blocks of schist and of the schist around lumps of gneiss.

The rapids are very impressive and powerful, and the vast blocks of the formation which have been disjoined and thrown on side and weathered for ages render this spot an exceedingly instructive one.

HALT 692. N. W. ¼, S. 14, T. 65-11. Gneiss and schists intermixed as usual, but less of the schists.

HALT 693. Centre S. W. ¼, S. 11, T. 65-11. Gneiss and schists elaborately interbanded. Mica schist here has little feldspar and is friable with much quartz.

HALT 694. Centre S. 11, T. 65-11. Painted Castle. An enormous promontory 75 feet high, which presents on the east a vertical wall a quarter of a mile long and 50 or 60 feet high. It is by far the most impressive and interesting rock view which I have seen in Minnesota. The façade of this vast castle-like structure is broken into towers and wings, overhanging outlooks and recessed porticoes. The entire mass is distinctly schistose, and the beds stand vertically. The architectural suggestions are further increased by the vertical striped coloration of the successive beds. We have here hornblendic columns almost black, epidotic columns green, red feldspathic columns of granulyte and gneiss brilliantly red; other columns pink and gray. Stripes of orange and black lichens further diversify the coloration. Not to describe further, I venture the opinion that this spectacle is worthy of comparison with the "Pictured Rocks" of Lake Superior, and I propose to name it the Painted Castle of Minnesota.

In lithological composition it reproduces the features described in the foregoing notes.

Rock 279. Diallagic dioryte forming one of the beds in the Painted Castle.

HALT 695. N. W. ¼, N. E. ¼, S. 2, T. 65-11. Gneiss and schist as before.

HALT 696. N. W. ¼, N. W. ¼, S. 2, T. 65-11. Gneiss and schist as before.

HALT 697. N. E. ¼, S. W. ¼, S. 35, T. 66-11. Biotite gneiss with almost a complete absence of schists. Bedding traceable. Strike N. 51° E.

HALT 698. N. W. ¼, N. W. ¼, S. 35, T. 65-11. Gneiss with little mica. No schists and no conspicuous bedding lines.

HALT 699 N. W. ¼, S. W. ¼, S. 26, T. 66-11. Granite so far as shown, with a little biotite.

HALT 699 *bis*. N. W. ¼, S. E. ¼, S. 27, T. 66-11. In Canada. Biotite granite with little mica.

HALT 700. S. E. ¼, N. W. ¼, S. 27, T. 66-11. Gneiss. Has general aspect of granulyte, but bedding planes are here and there revealed. Strike N. 75° E. The quartz is smoky and tends to give the rock a granitic aspect at first glance, but the (biotite) mica is in small quantity.

HALT 701. S. W. ¼, S. E. ¼, S. 22, T. 66-11. Gneiss with clear quartz and a little more biotite than exists at the last three Halts. The rock is also coarser.

HALT 702. N. E. ¼, S. E. ¼, S. 22, T. 66-11. Biotite gneiss nearly granite for solidity, but still showing beds. Strike E. and W.

HALT 703. N. W. ¼, N. E. ¼, S. 22, T. 66-11. More schists than gneiss. Even the biotite gneiss is thin-bedded. Here are thick beds of biotite schist and ellipsoidal lumps of this and other rocks all stirred together, as it were, in a common stew. Strike N. 70° E.

HALT 704. S. W. ¼, S. E. ¼, S. 15, T. 66-11. Schists and gneiss in a maze of confusion. Strike N. 88° E. Dip N. 39°. The gneiss is biotitic and the commonest schist is biotitic. The gneiss is in beds half an inch thick and upwards to two feet; but every bed is rendered uneven or contorted by the inclusion of splinters and chunks of schist.

HALT 705. N. W. ¼, S. W. ¼, S. 15, T. 66-11. A great mixture of biotite gneiss and biotite schist remarkably twisted together. The general appearance of one spot is shown below:

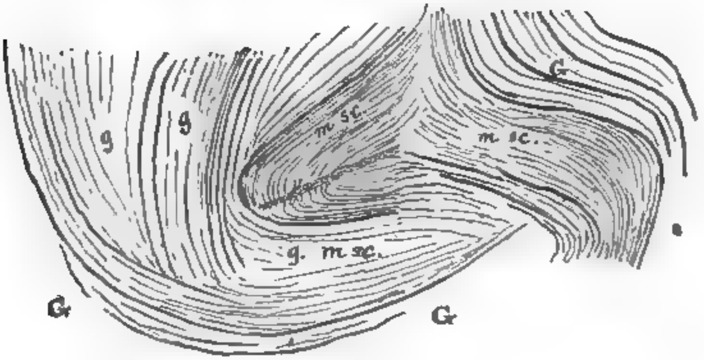

Fig. 42. Schist and gneiss intertwisted at Halt 705, on the boundary, near Crooked Lake.
m. sc. mica schist; g. gneissic; G. gneiss

HALT 706. S. W. ¼, N. E. ¼, S. 16, T. 66-11. Biotite gneiss and biotite schist interbedded as heretofore.

HALT 729. S. E. ¼, S. E. ¼, S. 16, T. 66-11. Gneiss and schist remarkably wound together. Strike unascertainable.

HALT 707. S. E. ¼, N. E. ¼, S. 17, T. 66-11. Ragged, schistic, warped in countless directions, gneiss itself schistic. Strike not certainly determinable, but in one place the beds are vertical, in other places dip in sundry directions.

HALT 708. Centre S. W. ¼, S. 17, T. 66-11. Biotite gneiss quite massive, but with interrupted bands of biotite schist with feldspar. Closely contiguous are found bands of biotite schist.

Memorandum.— Tower blasts are heard from here, a direct distance of 36 miles.

HALT 709. N. E. ¼, S. E. ¼, S. 18, T. 66-11. Biotite gneiss quite massive.

HALT 710. Near centre S. 18, T. 66-11. Biotite gneiss as above.

HALT 711. N. W. ¼, N. W. ¼, S. 18, T. 67-11. Biotite gneiss, interbedded with a dark syenite containing much diallage, some biotite and little quartz, also other beds of diallagic dioryte containing a pale green feldspar.

HALT 792. S. E. ¼, N. W. ¼, S. 13, T. 66-11. Biotite gneiss mostly coarse, and some schists; but half the formation is composed of a dark rock consisting of black lamellar hornblende and plagioclase, also some biotite.

Rock 280. Dioryte schist as above.

Rock 281. Dioryte schist from Halt 711.

HALT 713. N. W. ¼, N. W. ¼, S. 13, T. 66-12. Coarse granulyte and biotite gneiss.

HALT 714. N. W. ¼, S. 14, T. 66-12. Biotite gneiss interbedded with schist, either biotitic or diallagic, but much like Rock 280. Dip 30° N.

Rock 282. Biotite schist (diallagic?)

HALT 715. N. W. ¼, N. E. ¼, S. 15, T. 66-12. Island. Biotite gneiss very compact and with little biotite.

Rock 283. Biotite gneiss as above.

HALT 716. N. E. ¼, N. W. ¼, S. 15, T. 66-12. Island. Biotite gneiss poor in mica. Contains large angular pieces of an ambiguous rock which I think is dioryte schist.

HALT 717. N. W. ¼, S. E. ¼, S. 9, T. 66-12. Island. Biotite gneiss poor in mica, very compact, mostly coarse-grained. No bedding planes can be certainly determined. Glacial striæ south.

HALT 718. S. W. ¼, N. W. ¼, S. 9, T. 66-12. Biotite gneiss very compact, medium grain, poor in mica, like that at Halt 717, but a little finer.

HALT 719. N. E. ¼, N. E. ¼, S. 8, T. 66-12. Biotite gneiss, coarser than for some miles back, with red feldspar and a little more biotite. Exposed on the hills it gives them a bloody hue. The redness of the feldspar increases by weathering.

I find some beds with a deep red feldspar, very little quartz, crystals of a white or glassy feldspar, and an olive-greenish decaying mineral, which on the weathered surface, disappears, leaving cavities.

Rock 284. Decaying gneiss as above.

This bed strikes N. 60° E. with a dip of 85° S.

HALT 720. N. W. ¼, S. E. ¼, S. 5, T. 66-12. Island. Biotite gneiss, medium grain.

Rock 285. Biotite gneiss.

HALT 721. S. E. ¼, N. W. ¼, S. 5, T. 66-12. Biotite gneiss.

HALT 722. Canadian side, opposite N. W. ¼, N. E. ¼, S. 6, T. 66-12. Red biotite gneiss, coarse and poor in mica.

This locality is near the outlet of Crooked lake.

§ 15. IRON LAKE.

Iron lake is located on the national boundary west of Crooked lake. The American portion lies chiefly in T. 66-13, having a length of about three miles and an equal width. Only the eastern portion was explored, but as far as visited its shores are granite-bound and present the usual baldness and barrenness of granitic regions.

HALT 723. Falls into Iron lake, Canadian side. Red biotite gneiss. This formation is quite massive, scarcely any evidences of bedding being apparent; but lichens cover so much of the exposure that one can not be certain the traces of bedded structure are quite absent.

The falls are decidedly impressive. The volume of water is much greater than at Fall lake, but the descent I think about five feet less. I estimate it at 30 feet. Beyond is a further rapid descent of five feet, and moderate rapids continue for a quarter of a mile along the gorge. I judge the whole descent is not less than thirty-six feet. The scene ought to be photographed.

Rock 286. Red biotite gneiss, Halt 723.

HALT 724. American side of the falls. The formation shows a probable bedding with strike N. 62° E.

HALT 725. Canadian side near foot of rapids. Formation becomes schistose and includes beds of mica schist. On a second visit my attention was attracted by numerous fragments of a distinctly schistic character. Though not in place I am confident they are not far removed.

Rock 288. Biotite muscovite schist.

Rock 289. Gneiss distinctly bedded. From a fragment at Halt 725.

On the portage around the falls on the American side, I saw a fragment eight or ten feet in diameter showing similar bedding.

Rock 290. Coarse aggregation of quartz, feldspar and muscovite. This is from a fragment, but I saw plenty of it in placc afterward.

Rock 291. Muscovite chlorite gneiss. From a fragment three or four feet long and three inches thick, therefore not far transported.

HALT 726. S. E. ¼, N. W. ¼, S. 6, T. 66-12. Biotite gneiss. Strong indications of bedding with strike N. 80° E.

HALT 727. S. W. ¼, S. W. ¼, S. 6, T. 66-12. Lofty ridge of gneiss, the bedding planes being obscure. To the southeast at the distance of an eighth of a mile lies another similar ridge. The dark mineral in this also is biotite but is not abundant.

I walked over this ridge and found only obscure evidences o bedding—still I think unequivocal. One of the specimens preserved (Rock 287) shows this.

Rock 287. Biotite gneiss.

HALT 728. N. W. ¼, S. W. ¼, S. 6, T. 66-12. Island lying mostly in T. 66-13. Biotite gneiss quite coarse, occasional crystals of orthoclase an inch on a side, mostly much less. Biotite is certainly present in small quantity and no hornblende.

The result of observations carried west to the border of range 13, and north over the bounds of Town 67, is to show that no rock answering the text-book definition of granite occurs. All the granitoid rocks are essentially bedded.

§ 16. CARP LAKE.

Carp lake is separated from Basswood by rapids flowing into Basswood. The portage is about a third of a mile long and lies on the east of the rapids. It is frequently known as Prairie portage. It is part of the highway between the east and west. Carp lake consists of two portions, one of which is rudely cir-

cular and lies on the boundary; the other is a broad, bent arm, extending first southeast into American territory three-fourths of a mile, and then southwest an equal distance. The northern portion lies in a basin bounded by a hard, diabase-looking, almost strictly massive, quartzo-feldspathico-aluminous schists which I have heretofore designated graywacke. The southern portion is excavated in the vertical edges of sericitic and chloritic schists, whose trend is here about 60° east of north. The axis of the southern arm of the lake is almost exactly northeast and southwest. It will be noticed that the two trends are not quite coincident, the axis of the lake making an angle of about 15° with the strike of the strata.

The name here employed is the one which I find on the government plats. The next lake to the east is named Sucker lake, and the next, lying mostly in Canada, is known in our notes as Pseudomesser lake. But some confusion seems to exist. On a map published in 1884 by the Department of the Interior of the Dominion of Canada, the lake here called Carp is nameless; the next east is called Birch lake, and the third is set down as Carp. If the first is properly known as Carp, it will be well to avoid a duplication, and for the same reason, the well-known name of Birch lake in Town 61-11 and 12 should take precedence of this Canadian lake in the application of the name.

HALT 453. S. W. ¼, S. W. ¼, S. 1, T. 64-9. Graywacke schist containing some chloritic material.

HALT 454. Entrance to Carp lake. Canadian side. Graywacke schist like the last.

HALT 455. S. W. ¼, S. W. ¼, S. 1, T. 64-9. Graywacke schist.

HALT 456. S. E. ¼, S. W. ¼, S. 1, T. 64-9. Graywacke schist with fine, shining points, as if the formation were becoming micaceous, or perhaps sericitic. Veins of quartz.

HALT 457. N. W. ¼, N. E. ¼, S 12, T. 64-9. Sericitic schist thinly laminated and shining, but with considerable silica and some quartz veins, but much more quartz in segregated lenticular laminæ. Strike N. 76° E. Dip about vertical.

HALT 458. N. W. ¼, N. E. ¼, S. 12, T. 64-9. Chloritic schist — bedding vertical.

HALT 459. N. W. ¼, N. E. ¼, S. 12, T. 64-9. Argillite, distinctly slaty, a little sericitic. Strike N. 60° E. Dip vertical.

Rock 191. Argillite. Two specimens from Halt 459.

HALT 460. S. W. ¼, N. E. ¼, S. 12, T. 64-9. Island. Sericitic schist, brown, not very smooth, soft. Strike N. 60° E. Dip vertical or N. 85°.

HALT 461. Near centre S. 12, T. 64-9. Argillitic sericitic schist — slaty to massive. Strike N 60° E. Dip vertical.

Rock 192. Argillitic sericitic schist.

HALT 462. At mouth of stream from Newfound lake. Sericitic argillite, slaty, vertical.

Rapids occur at the mouth of this stream; but no portage is required.

HALT 612. S. E. ¼, S. E. ¼, S. 1, T. 64-9. Argillite, blue and slaty. Strike N. 50° E. Dip S. 80.

HALT 613. N. E. ¼, S. W. ¼, S. 1, T. 64-9. Graywake schist with many coarsely granular quartz veins. Bedding scarcely determinable.

HALT 629. N. W. ¼, S. W. ¼, S. 1, T. 64-9. Hard, apparently altered, chloritic schist. Intersected by dikes and veins of a material fine and hard and appearing to consist of a dark hornblendic or augitic matrix in which are embedded lenticules of reddish petrosilex. Strike N. 44° E. Dip vertical.

Rock 251. Sample of above dikes.

Immediately contiguous to this on the north, is a chloritic schist which weathers green.

§ 17. NEWFOUND LAKE.

This is a narrow lake separated by a brief portage from the southern extremity of Carp lake. Its main axis lies northeast and southwest. It has a length of nearly three miles and a mean breadth of about a third of a mile. It occupies parts of sections 11, 12 and 14 of T. 64-9. Its shores present the usual diversity of forest, but with some abundance of sapling growths. The north-northwest shore supplies the greatest abundance of pines, and these are mostly Norways. The southeast side exposes very few rocky outcrops. The surface is generally covered by a light deposit of drift. The northwest side, however, presents a succession of vertical cliffs of sericitic and argillitic schists which have a general trend making an angle of about 15 degrees with the axis of the lake.

HALT 463. N. W. ¼, S. W. ¼, S. 12, T. 64-9. Sericitic argillite in high cliff four rods back from shore — slaty, vertical.

Rock 193. Sericitic argillite from Halt 463.

HALT 464. S. W. ¼, S. W. ¼, S. 12, T. 64-9. Sericitic argillite very slaty, vertical.

HALT 465. S. E. cor. S. 11, T. 64-9. Island. Sericitic argillite, smooth, drab, vertical.

HALT 466. N. W. ¼, N. E. ¼, S. 14, T. 64-9. Island. Argillitic sericitic schist.

Rock 194. Argillitic sericitic schist.

HALT 467. S. W. ¼, S. E. ¼, S. 11, T. 64-9. Island. Sericitic felsitic schist, weathering with a rough conglomeritic aspect, exposing many small feldspathic knobs and winding films of chloritic matter.

HALT 468. N. E. ¼, S.W. ¼, S 11, T. 64-9. Graywacke schist in a high rounded outcrop.

Rock 195. Graywacke schist as above.

HALT 469. N. E. ¼, N. E. ¼, S. 15, T. 64-9. Graywackenitic sericitic schist.

HALT 470. N. E. ¼, S. W. ¼, S. 15, T. 64-9. Chloritic sericitic schist, soft, with finely wavy fracture.

Rock 196. Chloritic sericitic schist.

HALT 471. N. E. ¼, S. W. ¼, S. 15, T. 64-9. Sericitic schists, soft, vertical. Strike N. 60° E.

HALT 472. N. E. ¼, N. W. ¼, S. 22, T. 64-9. At portage to Moose lake. Chloritic schist, compact, with diabasic aspect.

HALT 610. S. W. ¼, S. E. ¼, S. 12, T. 64.9. Newfound lake. Argillite. Dip vertical.

HALT 611. S. E. ¼, S. W. ¼, S. 12, T. 64-9. Argillite, greenish, thin, slaty. Dip vertical.

§ 18. MOOSE LAKE.

This is another elongated lake, lying almost in the axis of Newfound lake, but making a slightly larger angle with the meridian. Like that, its basin is a vertical chasm chiseled out of the edges of the upright sheets of sericitic and argillitic schists. These schists rise in wall-like barriers along the borders of the lake, and in several places present scenes of imposing grandeur and impressive interest. At several points they afford smooth and beautiful slates suitable for industrial use. The lake lies wholly in the south half of T. 64-9. From Snowbank lake it is separated by a range of hills which appear to be formed chiefly of a recurrence of graywacke lying between the sericitic schists and a southern range of syenité.

HALT 473. At end of portage from Newfound lake. Argillite, a little felsitic, alternating with a chloritic, somewhat graywackenitic schist. Strike N 42° E.

HALT 474. S. W. ¼, N. E. ¼, S. 22, T. 64-9. Chloritic schist, soft and slaty.

HALT 475. S. E. ¼, N. W. ¼, S. 22, T. 64-9. Little island. Here is a dike of apparently diabase, 30 feet wide, bounded on both sides by thin-bedded sericitic schists. The schists are rather soft, with quartzose intercalations. In contact with the dike the schist is hardened.

Rock 197. Diabase from dike.

Rock 198. Sericitic schist from actual contact with dike.

HALT 476. N. W. ¼, S. W. ¼, S. 22. T. 64-9. Compact, chloritic, sericitic schist, rising in a bluff seventy feet high, and extending along shore a quarter of a mile.

HALT 478, S. E. ¼, N. E. ¼, S. 21, T. 64-9. Chloritic, sericitic schist, mostly fine and massive, partly breaking with a fine, wavy fracture.

HALT 479. N. W. ¼, S. E. ¼, S. 21, T. 64-9 Sericitic schist, slaty, bluish-gray, weathering buffish. A grand, enormous exhibition in a cliff fifty feet high and a third of a mile long. Would probably be suitable for roofing. Can be split into laminæ one-sixteenth of an inch thick.

Rock 199. Sericitic slate as above.

I saw great tables weathered out ten feet square — instead of disintegrating into chips, like the similar schist about Long and Fall lakes.

HALT 480. N. W. ¼, S. W. ¼, S. 28, T. 64-9. Sericitic schist, slaty, dipping S. 85°.

HALT 481. S. E. ¼, S. E. ¼, S. 29, T. 64-9. Chloritic argilite.

HALT 482. S. W. ¼, N. W. ¼, S. 31, T. 64-9. An enormous cliff of erupted material sixty or seventy feet high. At the base, near the water, some of it at least, is gabbro-like. Part way up and thence to the top, it appears like a diabase, but may be only a finer norite (gabbro). This probably is a great dike.

Rock 200. Diabase from cliff at Halt 482.

HALT 483. N. W. ¼, N. E. ¼, S. 31, T. 64-9. Buff sericitic slate, standing vertical.

HALT 484. S. E. ¼, S. 30, T. 64-9. Sericitic schist, thin, slaty. Strike N. 62° E. Dip vertical.

HALT 485. N. W. ¼, S. W. ¼, S. 29, T. 64-9. Argillite, beau-

tifully slaty, with smooth surfaces. Parts of it do not split easily. Strike N. 70° E. Dip N. 85°.

Rock 201. Argillite.

HALT 486. N. W. ¼, S. W. ¼, S. 29, T. 64-9. Sericitic schist, warped irregularly, rather hard, brownish.

HALT 487. N. E. ¼, S. W. ¼, S. 29, T. 64, 9. Chloritic, sericitic schist, greenish, with dark-green surfaces on the fracture, soft, slaty, but with occasional silicious laminæ. Dip vertical. Large exposure.

Rock 202. Chloritic, sericitic schist.

I was greatly perplexed to find a portage from this lake to Snowbank. This is partly due to the fact that only a faint trail exists, but more largely to the execrable condition of the government plats and the government survey. I found the large island on the east side, on the line between secs. 28 and 29, joined to the main land. I found many other errors in the plat. But more vexatious still, is the total absence of meander stakes, or if present occasionally, a perfectly illegible scrawl for a record.

§ 19. SNOWBANK LAKE.

Snowbank lake is about five miles long, and the main body of it is two and a quarter broad. The southern half of its outline is deeply indented by many irregular capes and peninsulas, and the surface of that part is much broken by islands, one of which is a mile in length. The lake lies in towns 64-8 and 9 and 63-9.

Snowbank lake has apparently been little frequented. Trails to and from it are very obscure and difficult. Much of the lake is shallow, and dangerous shoals and reefs are frequent. Many rock fragments, also, rise abruptly to and near the surface, in places where the water is generally deep. The dangers of canoeing are apt to be much increased by the prevalence of high winds, which sweep over the broad expanse of surface.

One can not enter this hydrographic basin without feeling impressed by its peculiar physical aspects. Compared with Burntside and Vermilion lakes, it has a distinctly more northern expression. Here is a marked diminution of pines, and a corresponding increase of white cedars and spruces. As along the northern shores of Lake Huron, the cedars fringe the lake and overhang the water in a somewhat continuous barrier. The long, beard-like lichen, *Usnea barbata*, hangs from the stunted

branches of the firs, and a growth of ancient mosses covers the surface of the earth with a deep and scarcely interrupted cushion. Here is a primeval condition of the wilderness. No fires have swept over the country. The geologist is compelled to camp nightly in the midst of the forest, and make his bed on a growth of damp mosses. The mossy bed is often a foot or two deep, but it is damp, and the underlying sharp fragments of syenite project upwards with very uncomfortable inequalities.

There are other contrasts with the lakes further west. The crows have disappeared, and the white-throated sparrow, so-called, is no longer heard, nor the feeble-voiced robin. But great gulls soar in considerable numbers overhead, and the great northern loon screams with voice startlingly loud and shrill. Fishes appear to be scarce, for we did not succeed in taking a single specimen with the hook.

The lake is bound in a massive rim of crystalline rocks. These are prevalently syenitic, but near the eastern extremity they become graywackenitic, hard, badly bedded, and decidedly diabasic in external aspect. Part of the northwestern shore was not visited; but it may safely be set down as syenitic.

HALT 488. N. E. ¼, S. W. ¼, S. 28, T. 64-9. On the Portage from Moose to Flask lake. Abundant fragments indicate the presence of a dike of norite in this ridge.

HALT 489. N. W. ¼, S. E. ¼, S. 28, T. 64-9. Chloritic diabasic schist, compact, greenish, with a base somewhat felsitic, and containing undefined grains of lighter feldspar.

HALT 490. N. E. ¼, N. E. ¼, S. 33, T. 64-9. Flask lake. Compact, graywackenitic sericitic schist, weathering rugged and knotted, as often seen before.

HALT 491. N. E. ¼, N. E. ¼, S. 33, T. 64-9. Flask lake. Porphyritic diabase of dark gray color, rather aphanitic, but with black, disseminated crystals of a mineral resembling augite, and of a light pinkish feldspar.

Rock 203. Porphyritic diabase.

HALT 492. N. W. ¼, N. W. ¼, S. 34, T. 64-9. Porphyritic diabase—same as Halt 491.

HALT 493. S. W. ¼, S. W. ¼, S. 27, T. 64-9. Diabase with same black crystals, but no feldspar crystals.

The portage to Snowbank lake is difficult to find. It is half a mile from the nearest point to Snowbank lake.

HALT 494. S. W. ¼, S. W. ¼, S. 27, T. 64-9. Diabase?—resembling the groundmass of that occurring at Halts 491 and 492,

but with no disseminated crystals either of augite or feldspar. Supposing this continuous with the rock at Halt 491, we have a mass half a mile wide. I presume it is continuous, for there is no schist seen along the southeast shore, and the diabase outcrops almost uninterruptedly. If such a dike of diabase rose here, there must have been a yawning chasm—one might perhaps say, an improbable chasm. But the distance indicated may mark the longitudinal extent. If so, it stands in general conformity with the strike of the schists.

Rock 203. Diabase from Halt 494. I find this rock extremely hard.

HALT 495. S. E. ¼, S. W. ¼, S. 27, T. 64-9. On portage from Flask to Snowbank lake. Diabase, very hard—same apparently, as at Halt 494.

HALT 496. N. W. ¼, N. E. ¼, S. 34, T. 64-9. End of portage. Diabase? a large boss, character quite like that at Halt 494, at the other end.

HALT 497. N. W. ¼, N. E. ¼, S. 34, T. 64-9. Diabase?

HALT 498. S. W. ¼, N. E. ¼, S. 34, T. 64-9. Porphyritic diabase as at Halt 491.

HALT 499. N. W. ¼, S. W. ¼, S. 35, T. 64-9. Syenite, fine-grained, with pale pinkish feldspar and little quartz.

Rock 204. Syenite from Halt 499.

HALT 500. S. E. ¼, N. W. ¼, S. 35, T. 64-9. Syenite with red feldspar and compact texture.

Rock 205. Syenite, Halt 500.

HALT 501. N. E. ¼, S. E. ¼, S. 35, T. 64-9. Reef. Red syenite, rather coarse.

HALT 502. S. E. ¼, N. E. ¼, S. 35, T. 64-9. Syenite.

HALT 503. S. W. ¼, N. W. ¼, S. 36, T. 64-9. Syenite, medium texture, white feldspar, and large, conspicuous and well-defined grains of black hornblende.

HALT 504. N. E. ¼, S. W. ¼, S. 36, T. 64-9. Syenite like last.

HALT 505. S. W. ¼, N. W. ¼, S 1, T. 63-9. Syenite, finer than at Halt 504, with a little larger proportion of hornblende.

HALT 506. S. E. ¼, N. W. ¼, S. 1, T. 63-9. Island. A mass of syenite.

HALT 507. S. E. ¼, S. W. ¼, S. 1, T. 63-9. Syenitic fragments cover the beach. No outcrop.

Made faithful examination of the creek emptying in here, with the view of reaching the large lakes from which it flows.

But the creek was impassable, and no portage could be found though we searched carefully both sides. From our failure I gave the name "Disappointment" to the larger.

HALT 508. N. W. ¼, N. E. ¼, S. 12, T. 63-9. On the creek, north side. Graywacke, but not much exposed.

HALT 509. N. E. ¼, S. W. ¼, S. 1, T. 63-9. Syenite but unusually fine, constituents in equal proportions.

HALT 510. Centre S. 1, T. 63-9. Syenite with red feldspar.

HALT 511. S. W. ¼, S. W. ¼, S. 31, T. 64-8. Syenite.

HALT 512. S. W. ¼, S. E. ¼, S. 31, T. 64-8. Syenite with red feldspar.

HALT 513. N. E. ¼, S. E. ¼, S. 31, T. 64-8. Syenite rather coarse. The dark mineral is greenish and rather dull; but small portions of it are a clear, glassy, yellowish green.

Rock 206. Syenite with greenish hornblende.

This syenite presents a horizontally-bedded structure, like that seen in Basswood lake, but the beds are much thicker. (Halt 440 *et seq*).

HALT 514. S. E. ¼, S. E. ¼, S. 31, T. 64-8. Syenite with red feldspar.

HALT 515. S. E. ¼, N. E. ¼, S. 31, T. 64-8. Syenite.

HALT 516. S. E. ¼, N. E. ¼, S. 31, T. 64-8. Syenite horizontally bedded.

HALT 517. N. E. ¼, N. E. ¼, S. 31, T. 64-8. Syenite like that at Halt 513.

HALT 518. S. E. cor. S. 30, T. 64-8. Syenite, fine, with glistening crystal faces of glassy feldspar.

HALT 519. S. E. ¼, S. E. ¼, S. 31, T. 64-8. Island. Fundamentally fine syenitic gneiss; but in places it is interbedded with fine hornblende schist. A dike of diabase 18 inches wide intersects the mass transversely. The bedding here is inconspicuous. We seem to have syenite in progress of passage to hornblende schist. In streaks I find also some muscovite.

Rock 207. Fine compact gneiss.

Rock 208. Fine compact gneiss. (I surmise one of these is diabase like.)

Rock 209. Interbedded gneiss and hornblende schist.

HALT 520. N. W. ¼, N. W. ¼, S. 29, T. 64-8. Syenite like that of Halts 513, 517.

HALT 521. N. W. ¼, S. W. ¼, S. 29, T. 64-8. Fine syenite gneiss interbedded with fine, compact, graywacke hornblende

schist. Similar outcrops were seen along the shore, but the water was too rough to land.

HALT 522. N. W. ¼, S. W. ¼, S. 29, T. 64-8. Very finely granular graywacke schist. There are shining particles, but they do not appear to be mica or hornblende. Still, some scales of muscovite are recognizable, and I have a suspicion that the rock is incipient mica schist.

Rock 210. Graywackenitic mica schist.

The rock is unmistakably bedded, and is interstratified with syenitic gneiss, muscovite gneiss and muscovite schist, with some feldspar. Some of the muscovite gneiss is quite coarse.

HALT 523. S. E. ¼, N. W. ¼, S. 29, T. 64-8. Fundamentally as at Halt 522. Some mica is disseminated, and some beds are typical mica schist. Obscure veins intersect the formation, and stand salient on weathered surfaces. This is again the so-called "sewed-up rock." Strike appears to be N. 28° E.

Rock 211. Graywackenitic mica schist with distinct mica on one side.

Rock 212. Mica schist from close proximity with Rock 211.

HALT 524. Near centre of S. 29, T. 64-8. Syenite with red feldspar.

HALT 525. N. E. ¼, S. W. ¼, S. 29, T. 64-8. Syenite, fine, with deep red feldspar.

Rock 213. Syenite as above.

HALT 526. S. E. ¼, N. W. ¼, S. 29, T. 64-8. Syenite—two sorts—one, medium texture with excess of hornblende disposed in rude layers and forming a gneiss; the other, very coarse, having crystals of bluish feldspar three-fourths of an inch long.

Rock 214. Gneiss.

Rock 215. Very coarse syenite.

HALT 527. S. E. ¼, N. W. ¼, S. 29, T. 64-8. A distinctly schistose rock, very compact, of that nondescript kind which I have denominated graywackenitic mica schist—same as Halt 522.

HALT 528. N. E. ¼, N. E. ¼, S. 29, T. 64-8. Schist very distinct—weathering a little greenish, but of a nondescript character, like the rock at Halt 527. There is, in addition, a diffusion of a little chloritic matter. The wrinkled and rough condition of the weathered surface also implies this. It contains beds of syenitic gneiss. Strike N. 11° E. Dip N. 80°.

In parts, the chloritic matter is conspicuous.

Rock 216. Graywackenitic, chloritic schist, Halt 528.

HALT 529. S. W. ¼, S. E. ¼, S. 20, T. 64-8. Appears like the graywackenitic mica schist in an exceedingly fine state. It is dark gray and has the aspect of argillite not fully developed. Strike seems to be N. 20° W. Dip N. 75°.

There is some mica schist.

Rock 217. Mica schist very fine, from Halt 529.

HALT 530. N. E. ¼, S. W. ¼, S. 20, T. 64-8. Chloritic sericitic schist. Strike N. 31° W. Dip N. 80°.

HALT 531. N. E. ¼, S. W. ¼, S. 20, T. 64-8. Fine, compact, chloritic, felsitic schist, varying from bed to bed—distinctly stratified but very solid.

Nearer the water the surface is perforated by thousands of little circular holes one-sixteenth of an inch in diameter and very uniform. They are mostly arranged in linear series conformable with lines of structure in the rock, but running in all directions in the different regions. Sometimes they appear somewhat as follows:

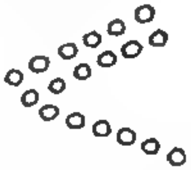

Fig. 43. Arrangement of holes in the rock surface at Halt 531. Snowbank Lake.

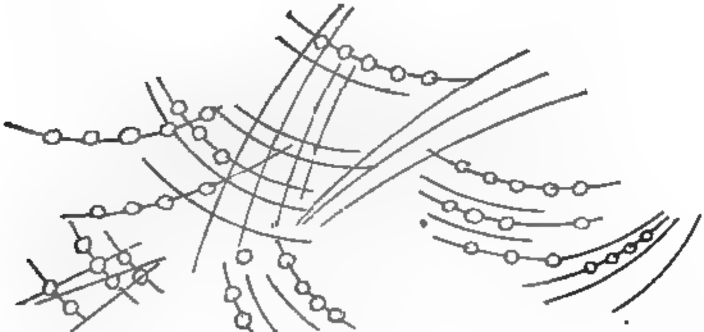

Fig. 44. Another arrangement of holes at Halt 531. Not thought to have any geological significance.

The series of pits are situated in curved grooves. The lines without pits are salient and vein-like. They separate the series of pits, and also intersect the general field.

Strike N. 38° W. Dip vertical.

Adjoining this on the north, the schist is graywackenitic mica schist.

HALT 532. S. W. ¼, N. W. ¼, S. 20, T. 64-8. Graywackenitic mica and hornblende schist. Some parts reached by atmospheric action are distinctly hornblende schist with much feldspar.

The narrow deep bay indicated on the plat is not here.

HALT 533. N. W. ¼, S. 20, T. 64-8. Fine dark-grayish very compact, graywackenitic-looking rock, some of which weathers brick-red, and some is greenish with epidote. It forms an escarpment 40 feet high. Divisional planes give some of it the appearance of horizontal stratification. It includes masses of black hornblende rock; and in places, hornblende schist is interbedded with the true bedding, which is nearly vertical. It contains, also, irregular masses of syenite.

HALT 534. S. E. ¼, N. E. ¼, S. 19, T. 64-8. A puzzling mixture again, containing graywacke schist, hornblende schist, syenite, felsitic schist, dioryte schist, etc.

Rock 217 *bis*.	Graywacke schist.	All mixed and interbedded.
Rock 218.	Dioryte schist.	
Rock 219.	Gneiss.	

HALT 535. S. E. ¼, N. E. ¼, S. 19, T. 64-8. Syenite—typical and unmixed.

This is an important observation, since it brings the crystallines far across the strike of the schists, and intimates that there may be, east of Snowbank lake, a connection between the White Iron syenites and the Basswood lake syenite. In accordance with this, the strike of the schists has recently been northerly and even northwesterly. This conjecture renders it all the more regretable that I could not get into Disappointment lake southeast of Snowbank.

HALT 536. N. W. ¼, S. W. ¼, S. 19, T. 64-8. Town line. Syenite.

Before dismissing Snowbank lake, it is due the government surveyors to testify that their work on the shores of the lake is even more execrable and misleading than that on Moose lake. There are several indications that some parts of the plat were laid down from memory. Thus particular features, besides being inexact, are quite erroneonsly located. Meander stakes, when present, are marked in the same illegible style as on Moose lake. These faults are more egregious in T. 64-8 than in T. 64-9.

§ 20. BOOT LAKE AND VICINITY.

Boot lake is a small body of water lying in an unbroken and almost unvisited wilderness in S. 21, T. 64-8. As it forms part of the long and difficult and badly platted route between Snowbank and Ensign lakes, it seems best to assign it to a special section. Its physical characteristics are identical with those of Snowbank lake. The geographical features of the region will be noticed in connection with the geology. On the east side of Snowbank lake is a deep narrow bay not laid down on the plat, and here a small stream conveys the drainage of the lake down a series of rapids into a small lake which I have named Shot lake. Other rapids connect this with Boot lake. A stream from Boot lake flows northeast into a stream from Jordan lake which I call Jordan creek; and this continues its course nearly north through a long estuary into Ensign lake.

HALT 537. S. W. ¼. N. W. ¼, S. 20, T. 64-8. On portage from Snowbank to Shot lake. Mongrel rock. Constituents of syenite and hornblende schist intermingled.

Rock 220. Syenitic, hornblendic schist.

HALT 538. End of portage, on Shot lake. Mongrel rock as before, with masses of syenite included; also veins of syenite.

HALT 539. N. W. ¼, S. W. ¼, S. 21, T. 64-8. Northeast side of Shot lake. Mongrel rock continues.

HALT 540. N. W. ¼, S. W. ¼, S. 21, T. 64-8. End of portage from Shot to Boot lake. "Sewed-up rock," a fine graywackenitic mica schist, intersected by obscure veins in many directions.

HALT 541. S. side N. E. ¼, S. 21, T. 64-9. On Boot lake. Graywackenitic or compact, chloritic schist, hard and greenish, apparently felsitic.

HALT 542. N. E. ¼, N. E. ¼, S. 21. T. 64-8. On boot lake. Greenish felsitic schist, very variable in texture. Strike N. 78° W. On weathered surfaces feldspar spots appear. Some parts contain large, light-colored felsitic patches.

Rock 221. Felsitic schist.

HALT 543. S. W. ¼. S. E. ¼, S. 16, T. 64-8. Northern extremity of Boot lake, on little bay not shown on plat. Sericitic schist, soft, light-drab, thinly laminated. Strike N. 80° W. Dip vertical.

Rock 222. Sericitic schist, from Halt 543.

The stream platted as entering at the southeast corner of Boot

lake does not exist. On the contrary, the little bay putting out at the northeastern angle is not platted; nor is the stream which finds exit here. This is not canoeable, but a very obscure trail leads along the east side of it.

HALT 544. S. W. ¼, S. E. ¼, S. 16, T. 64-8. One fourth mile on portage beyond Boot lake. Course N. 7° E. Sericitic schist, bluish, easily split. Strike N. 76° W. Dip 90°.

HALT 545. S. W. ¼, S. E. ¼. S. 16, T. 64-8. One-eighth mile on portage. Sericitic schist, bluish, warped, efflorescing, thin-laminated. Strike E. and W. Dip 90°.

A high cliff of this schist extends along the east side of the portage. It continues along the creek a distance of a quarter of a mile in a direction varying from N. 12° E. to N. 32° E. The strike of the vertical beds becomes N. 84° E. The cliff then trends more southeasterly.

In half a mile or less, the creek is met by Jordan creek, which is somewhat larger, and flows N. 53° W.

HALT 546. About N. W. ¼, S. W. ¼, S. 15, T. 64-8. On Jordan creek, one-fourth mile above junction with Boot Lake creek. Rapids all the way, and here is quite a pretty cascade over buffish, soft, sericitic slates standing vertical and having a strike N. 88° W. The cliffs rise on either hand 20 to 30 feet. On the top of the cliff stands a primeval forest, dense with undergrowth. But some thrifty pines — white and Norway, are seen, intermixed with spruce and cedars. One white pine measured 3 feet in diameter.

Above the falls, rapids continue at least a quarter of a mile. There is no trail, and therefore no indication of considerable water further up. I had to abandon the project, therefore, of getting into Jordan lake by this stream.

HALT 547. N. W. ¼, S. W ¼, S. 15, T. 64-8. Near beginning of portage beyond the stream. Greenish sericitic schist. Strike N. 88° W. Dip 60° S. This dip is in the creek; near by, in the bluff, the dip is vertical. Direction of the trail and creek N. 22° E.

The above Halt is at the northeast end of a pool one-tenth of a mile long, over which we floated the canoe. We then found rapids and took a poor trail on the west of the stream around them. This portage is about one-fifth of a mile.

HALT 548. About S. W. ¼, N. E. ¼, S. 15, T. 64-8. Sericitic schist, drab and soft and shaly.

This creek is broad, but shallow, and often obstructed by rocks

and fallen timber. Many places where the canoe must be hauled by men wading in the water, but there is no trail along the banks. Then another open place follows — one-tenth of a mile — then obstructions again. The plat is absolutely worthless. The stream finally widens out into an estuary setting northwest, instead of a delta setting northeast, and the mouth appears to be a third of a mile west of the place indicated.

§ 21. ENSIGN LAKE.

The best approach to Ensign or Mountain lake, and the only one which appears to be used, is at the west end, where a broad and canoeable stream (not so represented on the plat) flows out into Cap lake. From the northwestern angle of this, a high and dry portage, one-fourth of a mile long, connects with Carp lake. The stream which drains Cap lake into Carp is not canoeable; it is a continuous rapid, and no trail exists along its border, though we forced our way through. Ensign lake is long, narrow and irregular. It lies in the northern half of T. 64-8, and its main axes trend east and west. Its physiographic aspect is less severe and boreal than that of Snowbank; but the lake-fringe of white cedar and spruce is still a marked feature, and its waters are poor in fish. The lake lies upon the eroded vertical edges of a mass of schists whose strike has determined its main axes. It has about 14 miles of shore-line, and studies have been made at 55 Halts.

The faulty platting of the lake is partially corrected on the map accompanying this report. The geological description begins at the point of approach from Snowbank lake.

HALT 549. N. E. ¼, N. W. ¼, S. 15, T. 64-8. Ensign lake. Sericitic schist, yellowish-blue, partly quite shaly, partly more solid. Occasional fragments of a black, compact argillite appear, but they are not in the near neighborhood of an outcrop.

The formation varies from sericitic schist as above, to rough, compact argillite, and thin-laminated argillite.

Rock 223. Sericitic schist.

Rock 224. Compact, argillitic schist.

Rock 225. Thin-laminated argillite.

Strike N. 89° E. Dip vertical.

HALT 550. N. W. ¼, N. W. ¼, S. 15, T. 64-8. Island. Argillitic sericitic schist — even and slaty. Strike E. and W. Dip N. 85°. At the western end of the island the rock is more massive.

HALT 551. N. W. ¼, N. W. ¼, S. 15, T. 64-8. Argillitic sericitic schist.

HALT 552. N. E. ¼, N. E. ¼, S. 16, T. 64.8. Argillitic sericitic schist. Dip N. 75°, but possibly disturbed.

HALT 553. N. E. ¼, N. W. ¼, S. 16, T. 64-8. Bluish, argillitic sericitic slate. Strike N. 75° E. Dip 80°.

Rock 226. Argillitic sericitic schist.

HALT 554. N. E. ¼, N. E. ¼, S. 17, T. 64-8. Argillitic sericitic schist, bluish, not smooth, with minute glistening specks and a few black ones. Indications of a waxy pervasive matrix. Dip N. 75°.

Rock 227. Argillitic sericitic schist.

HALT 555. N. W. ¼, N. E. ¼, S. 17, T. 64-8. Chloritic, sericitic schist, weathering black and ragged, with many holes, circular, oblong and elongate, in the exposed edges of the beds. Immediately contiguous, the rock is highly sericitic, early crumbling to chips. Strike N. 74° E. Dip 86° S.

Rock 228. Sericitic schist.

HALT 556. S. E. ¼, S. W. ¼, S. 8, T. 64-8. Island. Felsitic schist varying to sericitic felsitic schist—compact, some portions hard and massive, others easily cleavable.

Rock 229. Felsitic schist (poroditic?).

Rock 230. Sericitic, felsitic schist.

The felsitic portion is in places porphyritic with undefined grains of feldspar. Strike N. 70° E. Dip vertical.

HALT 557. S. W. ¼, S. W. ¼, S. 8, T. 64-8. Island. Chloritic sericitic schist—bluish, soft, weathering vacuous, thin-laminated, but laminæ not really separating, many thin lenticules of felsitic matter interlaminated. Strike N. 74° E. Dip vertical.

HALT 558. S. E. ¼, S. E. ¼, S. 7, T. 64-8. Island. Argillitic sericitic schist. Dip vertical.

HALT 581. S. W. ¼, S. E. ¼, S. 7, T. 64-8. Sericitic argillite. Strike N. 64° E. Dip 76° N.

Rock 239. Sericitic argillite.

HALT 580. S. W. ¼, S. E. ¼, S. 7, T. 64-8. Near outlet of lake. Chloritic sericitic schist, same as at Halt 567—the chloritic matter bright green, and the formation having veins of quartz.

The stream flowing out of Ensign lake I call Ensign river. Its entrance is obstructed, but beyond it is broad and deep. It carries the waters of Ensign, Shot, Snowbank, Nameless and

Disappointment lakes, as well as those of Jordan, Ima, Thomas and Fraser lakes.

In this connection I notice the geology of Ensign river and of Cap lake into which it flows.

HALT 605. S. E. ¼, S. W. ¼, S. 7, T. 64-8. On Ensign river or estuary. Chloritic, sericitic argillite. Strike N. 52° E. Dip N. 75°.

HALT 606. S. W. ¼, S. W. ¼, S. 7, T. 64-8. Cap lake. Sericitic argillite. Strike N. 62° E. Dip vertical.

HALT 607. N. W. ¼, S. W. ¼, S. 7, T. 64.8. Argillite slightly sericitic. Strike N. 52° degrees E. Dip N. 75°.

HALT 608. S. W. ¼, N. W. ¼, S. 7, T. 64-8. Sericitic schist. Strike N. 38° E. Dip vertical.

HALT 609. S. E. ¼, S. E. ¼, S. 12, T. 64-9. Near outlet of Cap lake. Compact, hard argillite. Strike N. 52° E. Dip vertical.

HALT 579. S. W. ¼, S. E. ¼. S. 7, T. 64-8. Argillite. Dip 80° E.

HALT 578. N. E. ¼, S. E. ¼, S. 7, T. 64-8. Chloritic argillite with knots of apparently feldspathic matter, giving an uneven surface. Strike N. 62° E. Dip vertical.

HALT 577. N. W. ¼, S. W. ¼, S. 8, T. 64-8. Felsitic, sericitic schist, with disseminated grains of quartz. Composed of many alternating qualities. Flatened lenticular and globoid masses of syenite, and various qualities of the country rock are embraced in the bedding, and the beds are warped around them and fitted to them. General character like that at the point opposite—Halt 561. Strike N. 60° E.

HALT 559. N. E. ¼, S. E. ¼, S. 7, T. 64-8. Point. Argillitic sericitic schist.

HALT 560. N. W. ¼, S. W. ¼, S. 8, T. 64-8. Chloritic, sericitic schist.

HALT 582. S. W. ¼, S. E. ¼, S. 8, T. 64-8. Argillite, slaty, some of it smooth and fine, some rough, lenticules of quartz. Strike N. 64° E. Dip N. 75°.

Rock 240. Argillite.

HALT 583. N. W. ¼, S. E. ¼, S. 8, T. 64-8. Chloritic argillite, with grains of quartz and feldspar scattered through it. Strike N. 48° E. Dip N. 86°.

HALT 561. S. E. ¼, N. W. ¼, S. 8, T. 64-8. Point. Chloritic sericitic schist, varying to compact, hard, greenish felsitic schist, with darker green grains. Interbedded are many rounded

lumps of syenite, many lenticular masses, and many real beds—as also beds and lenticules of petrosilex, quartz and granulite. Strike N. 62° E. Dip vertical.

HALT 562. S. W. ¼, N. E. ¼, S. 3, T. 64-8. Argillitic sericitic schist in a cliff 15 feet high. Dip vertical.

HALT 563. S. E. ¼, N. E. ¼, S. 8, T. 64-8. Light sericitic schist similar to that at Halt 555, but more easily goes to fine chips.

HALT 564. S. W. ¼, N. W. ¼, S. 9, T. 64-8. Chloritic and graywakenitic schists in alternation—also some syenitic lenticules, and rounded lumps. It is noticeable that the laminæ are warped around the lumps as if the latter had been introduced as pebbles. The lenticules appear like segregations.

HALT 565. S. E. ¼, N. W. ¼, S. 9, T. 64-8. Chloritic sericitic schist. A dike-like bed of diabasic material 12 inches wide, stands perfectly conformable with the schist, and the contiguous schist is little, if any, altered. The schist contains lumps and interbeddings of dioryte. All these sorts of rocks also graduate into each other. The formation appears to have been a mixture of constituents, which at one point arrange themselves in one aggregation of minerals, and, at another point, in another aggregation.

Rock 231. Chloritic, sericitic schist with a felsitic band.

Rock 232. Schist in absolute contact with the dike. (The weathered side.)

Rock 233. Diorite in the above schist.

Rock 234. Syenite in the above schist.

HALT 566. S. E. ¼, N. W. ¼, S. 9, T. 65-8. Chloritic, sericitic schist. The chloritic constituent is bright green and gives the rock a showy appearance. Would be a handsome rock for polishing. It weathers rusty.

Rock 235. Chloritic sericitic schist — several specimens.

HALT 567. A few rods further east, this formation is intersected by massive veins of white, opaque quartz, which appears to cut the bedding transversely. These veins branch extensively, and in their ramifications become intimately mixed with the schist, giving it a granular, and finally, a simply silicicous constitution. Some portions of the schist here are massive and hard, with a russet color; but I find the schist in actual contact with the quartz not at all hardened or otherwise altered.

Rock 236. Relation of quartz and schist.

HALT 568. S. W. ¼, N. E. ¼, S. 9, T. 64-8. Argillite finely silicious but slaty. Strike N. 82° E. Dip 85° S.

HALT 569. N. W. ¼, N. E. ¼, S. 9, T 64-8. Chloritic sericitic schist with quartz grains disseminated through it, also some feldspar grains; intersected also by quartz veins of dike-form crossing the bedding diagonally. Rock contains also fragments of sericitic schist.

Rock 237. Chloritio sericitic schist with quartz grains.

HALT 570. N. E. ¼, N. W. ¼, S. 9, T. 64-8. Chloritic graywackenitic schist in a high cliff. Dip. S. 75.

HALT 571. S. W. ¼, N. W. ¼, S. 9, T. 64-8. Argillite, slate color, rather slaty structure, weathering greenish. Strike N. 67° E. Dip. S. 85°.

HALT 572. N. E. ¼, N. W. ¼, S. 8, T. 64-8. Solid schistose rock, consisting of interbedded argillite and felsitic schist. Strike N. 42° E.

HALT 573. N. W. ¼, N. E. ¼, S. 8, T. 64-8. Argillite, compact, non-slaty, mostly with disseminated grains of quartz and some feldspar.

Rock 238. Argillite and quartz.

HALT 574. N. E. ¼, N. W. ¼, S. 8, T. 64-8. Argillite distinctly bedded, but non-slaty. Strike N. 28° E. The strike varies five or ten degrees in the distance of 20 feet. Formation weathers in a very rugged and peculiar way.

HALT 575. Centre N. W. ¼, S. 8, T. 64-8. Sericitic argillite. Strike N. 41° E. Dip. S. 82°.

HALT 576. N. E. ¼, N. E. ¼, S. 7, T. 64-8. Argillite. gray-greenish, compact, with apparently a felsitic matrix, but very distinctly bedded. Strike N. 50° E. Dip vertical.

HALT 584. S. E. ¼, S. W. ¼, S. 9, T. 64-8. Sericitic argillite, thinly laminated and very slaty, the laminæ mostly waxy. There are many interlaminated sheets of quartz, and these occasionally branch across the laminæ of schist. Some of the laminæ are sharply plicated, and the included laminæ of quartz are quite conformable. But in such case, the quartz tends also to dissemination through the schist.

In one case I counted seven laminæ of quartz in the space of 4½ inches, and in another 7, less continuous, in the space of two inches. In the first case, the laminæ can be traced continuously six feet, and then they disappear in both directions under the earth.

Rock 241. Sericitic schist and one of 7 laminæ of quartz in 7 inches.

Rock 242. Plicated schist with quartz laminæ.

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HALT 585. S. W. ¼, S. E. ¼, S. 9, T. 64-8. Sericitic argillite.

HALT 586. S. W. ¼, S. W. ¼, S. 10, T. 64-8. Sericitic schist, very soft and thinly laminated. Strike N. 63° E. Dip 78° S.

HALT 587. N. W. ¼, S. E. ¼, S. 10, T. 64-8. Pale-buff sericitic schist, but packed full of grains of quartz and feldspar. On the weathered surfaces these grains stand prominent and whitish, giving the rock a granitic appearance. Some quartz veins run through it, and the bedding is warped and quite irregular. Strike N. 52° E. Dip?

Rock 243. Sericitic schist with quartz and feldspar grains.

HALT 588. N. W. ¼, S. E. ¼, S. 10, T. 64-8. Argillite. Strike N. 82° E. Dip S 75°. Glacial striæ S. 13° W.

HALT 589. Centre of S. 10, T. 64-8. Argillite packed with grains of quartz. Rock compact, hard, little slaty. Strike N. 82° E. Dip S. 76°.

Rock 244. Argillite with quartz grains.

HALT 590. S. E. ¼, N. W. ¼, S. 10, T. 64-8. Argillite smooth and slaty. Strike N. 73° E. Dip S. 80°.

HALT 591. N. W. ¼, N. W. ¼, S. 10. T. 64-8. Gravelly sericitic schist. It is packed with grains of quartz and feldspar. Strike N. 72° E. Dip vertical. Glacial striæ S. 12° W. and S. 32° W.

HALT 592. N. W. ¼, N. W. ¼, S. 10, T. 64-8. Felsitic argillite. Argillite reduced to the last degree of compactness and hardness by increase of silica and feldspar. Some is a fine homogeneous felsite of greenish-drab color, containing fragments of dark-gray argillite, shown in one of the specimens 245. Strike N. 70° E.

Rock 245. Felsitic argillite and argillitic felsite.

HALT 593. S. W. ¼, S. W. ¼, S. 3, T. 64-8. Felsitic argillite not so hard as the last.

HALT 594. N. E. ¼, N. W. ¼, S. 10, T. 84-8. Felsitic, sericitic schist somewhat silicious, weathering rather rough.

HALT 595. S. E. ¼, N. E. ¼, S. 10, T. 64-8. Sericitic argillite, rough and weathering harsh. Strike N. 78° E. Dip 60° S.

HALT 596. S. E. ¼, N. E. ¼, S. 10, T. 64-8. Rough, mostly massive sericitic schist. Strike not obtainable. Dip 45° S.

This unusual dip is taken on the shore, and I fear the planes of dip are in reality joints. Five rods away, however, the dip is S. 57°. In still another place it is S. 57°.

Some parts of the formation are extremely gravelly.

Rock 246. Gravelly sericitic schist.

HALT 597. S. W. ¼, N. W. ¼, S. 11, T. 64-8. Sericitic schist with disseminated grains and crystals of feldspar and some quartz.

HALT 598. N. W. ¼, S. W. ¼, S. 11, T. 64-8. Argillite a little sericitic, thin-laminated and slaty. Strike N. 73° E. Dip S. 70°.

HALT 599. S. W. ¼, S. E. ¼, S, 11, T. 64-8. Sericitic schist—partly argillitic and partly chloritic, with much interbedding of quartz and a good many lumps of coarsely granular quartz. Formation much like that of 584. Strike N. 86° E. Dip N. 75°.

The beds are much warped, and in places sharply plicated.

HALT 600. N. W. ¼, S. E. ¼, S. 11, T. 64-8. Argillite, dark-bluish, compact, but very distinctly laminated. Strike N. 72° E. Dip S. 54° and 64°. This formation is intersected by a dike of fine diabase, 18 feet wide and bearing N. 57°, and hence cutting the bedding.

Rock 247. Diabase from a dike at Halt 600.

The dike is about vertical.

The formation also includes a bed of coarsely granular quartz mixed with fragments of bluish-black argillite.

Rock 248. Quartz and black argillite.

On further examination this slate-bearing quartz is found in the form of a vein and not a conformable bed. In places it is ten inches wide and conformable, but the branches—still containing fragments of shale—run irregularly across the beds.

Searching further on the contact between the dike and the schist, I find a state of things as follows:

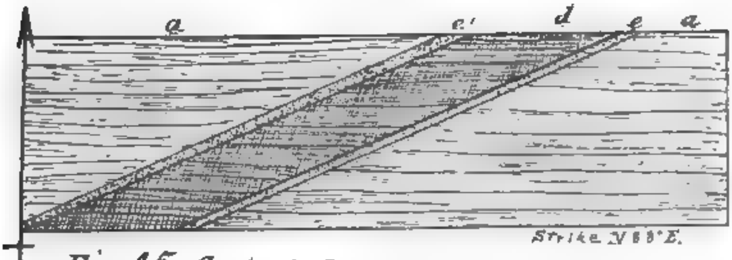

Fig. 45. Contact phenomena between a diabasic dike and argillite, Halt 600, Ensign Lake.

a. Argillite hardened in proximity to the dike.

d. The diabasic dike.

e. A bed 6 inches wide conformable with the dike and having

the appearance of hard, nearly black, argillite, with glistening points similar to those in the contiguous argillite.

e'. A layer similar to *e*, but more diabasic. On the whole, I think *e* and *e'* are a sort of selvage of the dike modified by contact with the argillite; as the contiguous argillite, on the other hand, is modified by the dike in becoming somewhat diabasic — for besides being harder, it is darker and inclines a little to hornblende or augite schist.

HALT 601. N. E. ¼, N. E. ¼, S. 15, T. 64-8. Graywackenitic argillite, compact, non-slaty. Strike N. 82° E. Dip S. 80°.

HALT 602. Centre N. E. ¼, S. 15, T. 64-8. A diabase dike rises like an outlier in the water near the shore, having a trend N. 76° E. conformably with the schists. It is about 27 feet broad. It holds disseminated grains of pale-greenish feldspar, and also a few fragments of glassy quartz. Some of the feldspar fragments are marked as follows:

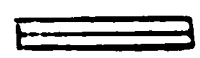

Fig 46. Feldspar individual with line along the middle, from a diabase dike, Halt 602, Ensign Lake

In this greatly magnified figure, a line is seen extending along the middle, giving an appearance as if the crystal had grown from the line in both directions.

Rock 249. Diabase from a dike at Halt 602.

HALT 603. N. W. ¼, N. E. ¼, S. 15, T. 64-8. Sericitic schist distinctly laminated, but not slaty. Some quartz veins. Strike N. 76° E. Dip S. 80°.

HALT 604. N. W. ¼, N. E. ¼, S. 15, T. 64-8. Argillite. Strike N. 74° E. Dip S. 85°. Contains lumps and lenticules of white quartz which warp the bedding more or less, according to size.

§ 22. SUCKER LAKE.

This, as before stated, is sometimes called Birch lake. It is so named on the Canadian map already cited. On a photographed copy of a manuscript map used by the United States Geological Survey, it is marked as Carp lake. It lies along the national boundary next east of Carp lake. Connected with Carp lake by a broad and navigable stream, a quarter of a mile

long, it has a total length of three and one-fourth miles, and an average breadth of half a mile. The eastern end bifurcates, and the southern branch, which contains the channel, is so disguised at its mouth by large islands, that the stranger would be apt to take the northern branch, which is a mere blind bay. It is separated from Pseudo-messer lake by rapids which are passed on a portage about a third of a mile long. Fishing seems to be excellent in Sucker lake, especially about the entrance into the southern arm.

HALT 614. Across the boundary from N. W. ¼, S. E. ¼, S. 1, T. 64-9. Island on Canadian side ("Interlaken"). Sericitic schist, soft, slaty. Strike N. 46° E. Dip vertical.

HALT 615. S. E. ¼, S. E. ¼, S. 1, T. 64-9. Graywacke in a high cliff. It may be bedded. but I could not see the evidence from the face of the cliff. I would suppose it to agree with the graywacke schists in Carp lake, but its composition seems to be hornblende or augite and a feldspar. In contact is a rough argillite.

HALT 616. N. E. ¼, S. E. ¼, S. 1, T. 64-9. Rough argillite, distinctly sericitic under the lens, appearing as if transitional to mica schist. The weathered surface is black and ragged, looking much like a stream of cooled lava, while soft and laminated in hand specimens, the bedding is exceedingly obscured on the weathered surface of the formation,

HALT 617. N. E. ¼, S. W. ¼, S. 6, T. 64-8. Chloritic sericitic schist of very uneven composition, and rough surface. Strike N. 60° E. Dip vertical.

HALT 618. N. W. ¼, S. E. ¼, S. 6, T. 64-8. Sericitic schist, soft, a little argillitic, dun. Strike N. 36° E. Dip vertical.

HALT 619. N. W. ¼, S. E. ¼, S. 6, T. 64-8. Sericitic schist buff and slaty. Dip vertical.

HALT 620. N. E. ¼, S. E. ¼, S. 6, T. 64-8. Sericitic argillite, alternating with sericitic schist, with interlaminations of quartz and some small veins. Strike N. 48° E. Dip vertical.

HALT 621. S. W. ¼, N. W. ¼, S. 5, T. 64-8. Sericitic schist, light-gray surface of laminæ granular. Contains lumps of vitreo-granular quartz, around which the bedding is warped. In one case I see the longer dimension of the lump directed across the bedding, and the laminæ abutting against its sides. Strike N. 40° E. Dip vertical.

HALT 622. N. W. ¼, N. W. ¼. S. 5, T. 64-8. Argillite,

rather hard and compact in the mass, but distinctly slaty. Strike N. 46° E. Dip 84° S.

HALT 623. S. W. ¼, S. W. ¼, S. 33, T. 65-8. Argillite, slaty but rather hard. Strike N. 52° E. Dip vertical.

HALT 624. N. W. ¼, S. E. ¼, S. 33, T. 65-8. Sericitic argillite, rather massive, but distinctly laminated. Contains lumps of quartz, some of which inclose fragments of schist still conformable with the formation. Strike N. 56° E. Dip S. 80°.

HALT 625. N. W. ¼, S. W. ¼, S. 34, T. 65-8. Commencement of portage to Pseudo-messer lake, argillite, blue and slaty. Strike N. 48° E. Dip vertical.

HALT 626. S. E. ¼, N. W. ¼, S. 34, T. 65-8. East end of portage. Argillite, dark, fine, slaty, with some quartz layers. Strike N. 50° E. Dip vertical.

Rock 250. Argillite, fine, dark.

HALT 627. (Canada.) S. E. ¼, S. W. ¼, S. 32, T. 65-8. (As of Minnesota.) Argillite, slate-color and slaty. Strike N. 52° E. Dip S. 80°.

HALT 628. (Wind I. Can.) N. E. ¼, N. W. ¼, S. 32, T 65-8. As of Minnesota. Sericitic schist. Strike N. 22° E. Dip vertical. On the north side of this island it is knotted up with a good deal of quartz.

§ 23. KNIFE LAKE.

Mo-ko-man, or Knife lake, stretches along the national boundary 9¾ miles. It connects with Otter Track lake on the east, and with Pseudo-messer lake on the west; but between it and the latter is an interval of 1½ miles occupied by a stream broken by four rapids and in the intervals expanded into little lakes which, beginning at the east, we have named Potato, Seed and Melon lakes. For convenienee of reference and description, Knife lake may be regarded as consisting of the main body and four arms. Arm I is the easterly attenuation of the lake, connecting with Otter Track lake. Arm II extends southeastward in S. 14, T. 65-7, and continues a quarter of a mile into S. 18, T. 65-6. Arm III lies wholly in S. 23, T. 65-7 and trends eastward. Arm IV starts from the northeast corner of S. 28, T. 65-7 and continuing through sections 27, 22, 23 and 24, passes into T. 65-5 and covers portions of sections 19, 18, 20, 21, 17, 16 and 15, having a length of about seven miles, and a breadth varying from a

quarter of a mile to a mile. An arm which might be named Arm IV, protrudes into Canada from the same part of the lake with which Arm II connects.

This lake is commonly approached along the boundary. It may also be reached from Lake Kekekabic by four short portages and three small lakes. The exit from Kekekabic is near the centre of N. E. ¼, S. E. ¼, S. 34, T. 65-7, and the portage leads nearly north a quarter of a mile to Pickle lake. The exit from this is at a shallow bay near the middle of the north side; and the portage leads northwest to the nearest point of Spoon lake, an eighth of a mile From this, at the nearest point to Doughnut lake, is a short portage; and from the most westerly point of the latter lake, is a fourth portage, a third of a mile long, leading west into the nearest part of Arm IV of Knife lake. The locations of these portages are somewhat concealed, and one uninformed will be likely to lose much time in searching for them.

The course of the observations will proceed from Lake Kekekabic over the portages and lakes last mentioned, and westward to Pseudo-messer lake. This route covers all that has been observed by the writer on Knife lake and immediate vicinity.

HALT 875. N. E. ¼, S. E. ¼, S. 30, T. 65-7. On portage to Pickle lake. Outcrop of slates, quite slaty and evidently a transition from the green schists occurring on the shore of Lake Kekekabic at Halt 854, to argillitic chlorite slates.

HALT 876. S. E. ¼, N. E. ¼, S. 34, T. 65-7. N. side Pickle lake. Dark argillite on the beach, and it seems to extend into a long hill stretching N. E. and showing much exposed rock which weathers quite light colored. The slates stands vertical.

HALT 877. S. W. ¼, S. E. ¼, S. 27, T. 65-7. Rough argillitic slate, graywacke-like and veined with quartz. The portage north out of Spoon lake is at the head of a little bay, behind a bit of an island, and concealed by a fallen tree.

HALT 878. S. W. ¼, N. W. ¼, S. 17, T. 65-7. End of portage, on Knife lake. Black, silicious argillite, not very slaty, with much pyrites. Fragments of Ogishke conglomerate and of the green shale on shore, much worn.

HALT 879. S. E. ¼, N. E. ¼, S. 28, T. 65-7. Island. Silicious slate.

HALT 880. N. W. ¼, S. E. ¼, S. 29, T. 65-7. Dark silicious (?) argillite. On close inspection the rock seems more felsitic than silicious. Strike N. 58° E. Dip vertical. Glacial striæ S. 24° W.

HALT 881. S. W. ¼, N. W. ¼, S. 36, T. 65-8. End of portage out of Knife lake. Dark argillite, very slaty, fels.tic. Strike N. 73° E. Dip vertical.

HALT 882. On portage from Potato to Seed lake. Argillite. Dip vertical.

HALT 883. S. E. ¼, N. W. ¼, S. 35, T. 65-8. Argillite, continuously slaty.

HALT 884. N. W. ¼, S. W. ¼, S. 35, T. 65-8. Argillite with vertical dip, compact. Strike N. 63° E.

Similar black, silicious slates continue along the shores of Pseudo-messer lake north of the boundary to a distance of at least two miles.

§ 24. IMA LAKE.

It was stated in section 20, when referring to Boot lake and vicinity, that the conspicuous stream shown on the government plat as flowing out of Jordan lake, is much broken by rapids and not canoeable, and no trail rendered practicable the approach to Jordan and Ima lakes from the direction of Snowbank. But a fair trail exists from the eastern extremity of Ensign lake (Halt 600) to Illusion lake. The distance is a mile and a quarter and it strikes Illusion lake on the north side. From the southeastern extremity of this lake, which is less than half a mile long and about a quarter of a mile broad, located in the S. E. ¼, S. 13, T. 64-8, another portage of about an eighth of a mile leads over a ridge of gabbro to Ima lake. Both these lakes are set in a frame of gabbro. Illusion lake is on the transition from schists to gabbro, and some interesting varieties of rock occur, but the general features of the shores of Ima lake are monotonous. For this reason but few halts are indicated, though a large number of exposures were examined. Personally the writer did not visit the north shore.

Ima lake is located chiefly in sections 18, 19 and 20, T. 64-7. It has a length of about two miles and a width of about two-thirds of a mile.

HALT 732. N. W. ¼, N. E. ¼, S. 14, T. 64-8. A few rods on the portage from Ensign lake. Sericitic schist — horizontal, but probably slidden down the hill.

HALT 733. N. E. ¼, N. E. ¼, S. 14, T 64-8. Graywacke. Strike N. 62 E.

HALT 734. End of portage, on Illusion lake, north side. The

rock is obscure. In places it has a diabasic and unbedded aspect; in other places it is distinctly bedded, especially on weathering, and it looks some like nascent mica schist. In many places it is much intersected by veins, and sometimes presents the appearance of the "sewed-up rock."

HALT 735. S. W. ¼, S. E. ¼, S. 13, T. 64-8. Illusion lake. Norite (or gabbro). Coarse, dark, disintegrating; seams composed of labradorite and augite, with a little biotite.

Rock 295. Norite as above.

HALT 736. S. W. ¼, S. E. ¼, S. 13, T. 64-8. Illusion lake. Rock the same as Halt 735. This I suppose to be the rock called gabbro in the northwest.

HALT 737. S. E. ¼, S. E. ¼, S. 13, T. 64-8. Illusion lake. Rock as at Halt 735. Also a rock similar but finer and more like diorite.

HALT 738. Island in Illusion lake, east of a little wooded island. Rock bedded, but the beds are twisted and wrapped to an extreme extent, having on one side a northward dip, and on the other a southward. Most of the rock resembles more or less completely that at Halt 734, but generally it is more altered.

Rock 296. Rock from little wooded island.

Rock 297. Rock from little wooded island, Illusion lake.

These are apparently the constituents of gabbro, but not yet organized — containing also some biotite.

HALT 739. S. E. ¼, S. E. ¼, S. 13, T. 64-8. Ima lake. Termination of portage. The formation, as anticipated, is gabbro. This rock outcrops at frequent intervals along the west shore, and around the little bay at the west end.

HALT 740. N. E. ¼, N. E. ¼, S. 24, T. 64-8. An outcrop of gabbro much rounded by weathering, and in a decaying state.

HALT 741. S. E. ¼, N. E. ¼, S. 44, T. 64-8. Gabbro.

HALT 742. N. E. ¼, S. W. ¼, S. 19, T. 64-7. Gabbro in a huge wall.

HALT 743. S. W. ¼, S. E. ¼, S. 19, T. 64-7. Gabbro.

HALT 774. N. E. ¼, S. E. ¼, S. 19, T. 64-7. Gabbro. A solid wall extends along this shore for the distance of half a mile. Along the eastern shore gabbro outcrops at frequent intervals.

§ 25. THOMAS LAKE.

In the attempt to reach Thomas lake from Ima lake, it was supposed the stream so conspicuously platted might be serviceable, but the outlet at Ima lake was so dimished as to leave

doubt of its real existence. A trail starts out, however, on the section line between sections 17 and 20, T. 64-7, and, in the course of half a mile, leads to a lake two-thirds of a mile long, not indicated on the plat, though appearing to lie on the section line between sections 20 and 21. From the southern extremity of this is another trail of a quarter of a mile, leading to a little lake in the N. E. ¼, N. E. ¼, S. 29; and from this another portage of equal length leading to a little rounded bay not represented on the plat. This is a part of Thomas lake. This lake is located chiefly in T. 64-7, but extends a third of a mile into 63-7. It is a little over two miles long, with a mean breadth of two-thirds of a mile. The lake is hemmed in on all sides by towering masses of gabbro. In consequence of the uniformity of geological character but few halts are noted, though every exposure was adequately examined. The northern shore was not personally seen by the writer—a line of perhaps two miles.

HALT 745. S. E. ¼, N. E. ¼, S. 20, T. 64-7. Swell lake, at end of first portage from Ima lake. Gabbro.

HALT 746. S. E. ¼, N. E. ¼, S. 20, T. 64.7. Swell lake. Gabbro, but finer grained, with much horizontal jointed structure.

Rock 298. Gabbro of finer grain.

HALT 747. S. E. ¼, S. E. ¼, S. 29, T. 64-7. Thomas lake. Gabbro, coarse, decaying—a low outcrop.

HALT 748. S. E. ¼, S.W. ¼, S. 32, T. 64-7. Gabbro. The main mass is coarse as usual, rising in the point and passing beneath water-level. But above this, mostly under water, are plates of fine-grained gabbro, which are washed in large fragments on the beach.

Rock 299. Fine-grained gabbro.

HALT 749. S. W. ¼, S. W. ¼, S 32, T. 64-7. Gabbro with small crystals not homogeneously distributed.

Rock 300. Formative gabbro as above.

Rock 301. Gabbro from Halt 749.

HALT 750. N. W. ¼, S. 4, T. 63-7. Gabbro.

All the windings of the west, south and southeast shores of this lake were carefully examined, and no rock was discovered but gabbro, and little variation was observed in this, except in fineness.

§ 26. FRASER LAKE.

Fraser lake lies in the southeastern quarter of T. 64-7 — being mostly embraced in sections 22 and 23, though a long and narrow arm extends into the southern part of sec. 27, and the east end reaches nearly to the middle of sec. 24. The government plat of the lake is exceedingly inaccurate and misleading. The long promontory shown on the southeast side, instead of being broad-based, is so nearly cut off that the water actually connects at certain seasons. The long narrow indentation shown as extending northeastward on the plat, actually extends southeastward, with a long narrow bay running up on the west. Similar misrepresentations exist on the northern border.

The approach to the lake is easy over a broad cut-out portage of a quarter of a mile along the west side of the rapids into Thomas lake. These may be found in S. E. ¼, S. W. ¼, S. 27. The exit toward the east is easily found, and leads to a series of small lakes and short portages into the Little Saganaga. The exit to the north, however, is considerably concealed. In the S. E. ¼, S. W. ¼, S. 14, a short portage exists leading into a lake which the survey named Wisini, two-thirds of a mile long, but not indicated on the plat. No portage or trail, however, leads out of this lake, and the survey was compelled to cut one N. N. E. into a little lake which was called Syrup lake. From the northern extremity of this another portage was cut, half a mile long, N. N. E. into Shoo-fly lake, which lies mostly in the S. E. ¼, S. 11. Near the northern end of this, a short, dry, much-used portage leads westward into a river-shaped lake, thence named River lake, from the northern side of which at the elbow, a poor portage a third of a mile long, leads north into the most southern point of Kekekabic. It is probable Shoo-fly lake may be reached directly from Fraser lake, over a portage which escaped our observation.

These lakes all rest in depressions of a great gabbro formation. On the northeast of Fraser lake, the hills of gabbro rise 70 or 80 feet above the lake. It is in this formation, as I am informed, that gold was reported to exist. The mine for a time so famous, is located on the north shore, in S. E. ¼, S. W. ¼, S. 14, T. 64-7.

From the uniformity of the geology, only a few localities will be specifically noticed.

HALT 751. N. E. ¼, S. W. ¼, S. 27, T. 64-7. Southern point of Fraser lake. Gabbro in a massive exposure. This is where

the road strikes this lake which we find cut out most of the way from Carp lake—a winter road for transportation to Fraser lake.

Here on the beach are fragments of silico-argillitic slates.

HALT 752. About S. 23, T. 64-7. This Halt can not be precisely located in consequence of the great imperfection of the plat. The great point from the southeast shore is deeply constricted near the base—quite unlike the plat. This isthmus is not over four rods wide, and is covered in high water.

On this I found large fragments of silicious argillite.

A very massive outcrop of gabbro extends along the eastern shore of the lake north of the promontory.

The modifications made in this part of the plat could only in part be represented on the map accompanying this report.

Wisini lake is quite walled in by massive outcrops of gabbro.

Syrup lake is surrounded by a marsh, except on the north side.

Shoo-fly lake is surrounded by upland on all sides.

Much of the territory about Fraser and contiguous lakes has been burned over. Most of this is now covered by a dense growth of young aspens.

HALT 753. S. W. ¼, N. E. ¼, S. 11, T. 64-7. "Muscovado gabbro," but with a few disseminated grains of reddish feldspar giving the rock a slightly syenitic aspect.

"Muscovado" is a term here applied to a finely granular gabbro or gabbroloid having accessions of reddish feldspar as above noted, as well as a few disseminated grains of quartz.

This locality is on the north side of River lake near the passage north into the broad parallel arm.

An outcrop of the same occurs on the north side of the north arm a few rods east of the portage.

§ 27. KEKEKABIC LAKE.

The principal area of this lake lies in towns 64 and 65-7, but a portion of the elongated eastward extension covers parts of 29, 30, 31 and 32, T. 65-6. Its longitudinal axis is 4½ miles long and trends N. 70° E. It lies in a broken country, and several rounded summits rise from 100 to 200 feet above the lake. Its shores possess much geological interest as showing the transition from the gabbro region of Fraser lake to the black slates of Knife lake.

It affords the first glimpse, also, of a remarkable conglomerate which, further east, attains a great development, and receives the name of Ogishke Conglomerate.

We were unable to take any fish in this lake with the ordinary trolling hook.

HALT 754. S. W. ¼, S. E. ¼, S. 2, T. 61-7. Rock weathering reddish, and when broken appears to contain a dark mineral having a chloritic aspect, and giving the whole a banded texture.

Rock 302. Chloritic gneiss.

HALT 869. S. W. ¼, N. W. ¼, S. 2. T. 64-7. Only fragments, and not all of one sort. Many of reddish chloritic gneiss, like that seen along the south shore.

HALT 870. S. E. ¼, N. E. ¼. S. 3, T. 64-7. East end of Plum island. Rock of red feldspar and a dark chloritic substance with probably considerable quartz. Exceedingly tough. The constituents vary in different parts and show a banded arrangement.

Rock 377. Felsitic schist.

HALT 755. N. W. ¼, N. W. ¼, S. 2, T. 64-7. Seems to be essentially feldspar, chlorite and quartz, and is consequently the same rock as began to appear at Pipestone rapids. (Halts 640 to 655.)

Rock 303. Compact, chloritic gneiss.

HALT 871. West end of little island in N. W. ¼, N. W. ¼, S. 2, T.-64-7. Rock essentially like that at Halt 870, but containing large crystals of feldspar.

Rock 378. Porphyritic, chloritic gneiss.

HALT 872. North side of same island. Here the green and the feldspathic ingredients instead of being blended into a gneiss, remain separate in bands.

Rock 379. Green rock and granulitic interbanded. The green portion is not distinguishable from the green rock occurring at numerous places, and I feel confident that it is essentially chlorite, and the dark shining scales are chlorite.

This formation presents a rude, nearly horizontal bedding.

HALT 756. S. E. ¼, S. E. ¼, S. 35, T. 65-7. Chloritic gneiss, similar to Rock 303, but the orthoclase occurs in larger grains, from a sixteenth to half an inch in longest dimension. The forms and positions of these grains indicate a bedded influence in the rock.

Rock 304. Compact, chloritic gneiss, coarser grained.

HALT 757. N. E. ¼, S. W. ¼, S. 36, T. 65-7. West end of Stacy island. This seems to be essentially the same sort of rock in which the feldspar has accumulated in a porphyritic fashion. This sort of porphyry is what I subsequently designated "porphyrel." It contains here small black scales of apparently chlorite.

Rock 382. A small piece of this porphyrel showing indication of conglomeritic constitution.

Rock 305. Chloritic porphyrel.

HALT 758. On south side of Stacy island. Cliffs sixty feet high, broken down vertically. Rock is bedded somewhat obscurely. Strike N. 53° E. Dip N. 85°. Formation consists of gneissic beds similar to those last described, alternated with dark—perhaps slightly greenish, but distinctly blackish—heavy beds having a slaty aspect.

Rock 306. Slate, compact, argillitic, as above, with some feldspar crystals.

HALT 759. Near eastern end of Stacy island. At the bottom of the bluff a well-marked conglomerate rises above water-level. It weathers rough, is slightly brecciated, dark colored, composed of fragments of fine diabase, dark silicious schist, red jasper, black flint, all imbedded in a fine matrix of dark color, looking somewhat like the overlying dark slate. The conglomerate dips N. 70°, with a strike N. 52° E.

The conglomerate is apparently conformable with the overlying formation, and passes upward into it through the intervention of a partial conglomerate and rough, uneven bed.

Rock 307. Conglomerate from Stacy island.

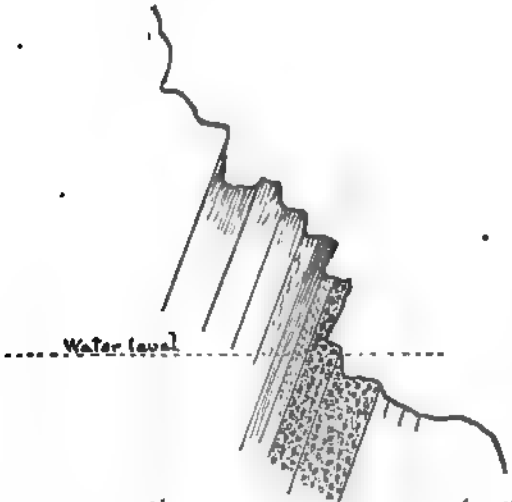

Fig 47. Subterposition of conglomerate, Halt 759, Stacy Island, Lake Kekekabic.

On the main shore nearly opposite, and extending eastward, are cliffs eighty feet high, composed like Stacy island, of dark, very compact schist, and having conglomerate at water-level.

HALT 760. S. W. ¼, N. W. ¼, S. 31, T. 65-6. Compact, diabase-like groundmass, with disseminated, rectangular crystals of feldspar.

Rock 308. Porphyritic, diabase schist.

HALT 761. S. E. ¼, N. E. ¼, S. 30, T. 65-6. Compact, porphyritic diabase.

Rock 309. Porphyritic diabase.

Back from the shore a bluff rises, composed of a fine, slate-colored rock, distinctly bedded and resembling the compact slate of Stacy island. The dip, if I do not mistake, is N. 35° and the strike is N. 28° E — both quite anomalous.

I attempted to find the relation of the slate and the diabase; and, climbing to the top of the cliff, found a mass of the diabase which I traced down to a level ten or fifteen feet below the occurrence of slate, and hence I inferred that it intersects the slate. In fact, I uncovered almost to the plane of contact. I was thus led to think the diabase erupted. Thirty feet west, however, actual contacts were easily seen, but they are not dike-like. Fragments of the diabase occur within the

slate, and the transition between them is not abrupt, but gradual. The slate, however, in the vicinity, is hardened and diabasic.

Rock 310. Dark slate, silicious.

Rock 311. Slate-colored slate, softer.

Rock 312. From a dike across the slate.

HALT 762. S. E. ¼, N. E. ¼, S. 31, T. 65-6. Shale, hard, varying from a slaty condition to a diabasic. I find the diabasic portions included in the slaty. The slaty structure is vertical and strikes N. 13° E.

HALT 763. S. W. ¼, N. W. ¼, S. 32, T. 65-6. Fine, hard, brittle diabasic rock, with a subslaty structure.

HALT 764. N. W. ¼, N. W. ¼, S. 32. T. 65-6. Fine, hard, bluish-slate, weathering light. The most conspicuous slatiness is nearly horizontal, but plates split also in a vertical direction; and this vertical cleavage seems to be coincident with the bedding.

Rock 313. Fine, hard, bluish slate.

HALT 765. S. E. ¼, S. W. ¼, S. 29, T. 65-6. Diabasic slate.

HALT 766. S. E. ¼, S. W. ¼, S. 29, T. 65-6. At portage eastward. Diabasic slate. A large and lofty exposure. There seem to be sedimentary bedding planes standing nearly vertical, and having strike N. 23° E. There is also an extensive set of planes of schistosity striking N. 87° W.

Ascending the hill on the west I find the slatiness of the formation not much apparent except in weathering. I find many intrusions of diabase and porphyritic material, sometimes in the form of dikes, sometimes by mixing with the slate and being included in it.

On the summit, which is perhaps 100 feet above the lake, I find the strike N. 38° E., and the dip S. 85°. The glacial striæ are S. 18° W.

HALT 845. S. E. ¼, S. W. ¼, S. 29, T. 65-6. Porphyrel quite distinctly conglomeritic.

Rock 362. Porphyrel from Halt 845.

HALT 846. S. E. ¼, S. E. ¼, S. 30, T. 65-6. Foot of Mallman's peak. Graywacke-like and silicious slate.

Rock 363. Graywacke-like.

The formation presents portions which are almost sericitic.

Mallman's peak, as ascertained by aneroid, is 230 feet high — above the lake.

A sample of the rock from the summit is not different from the gray rock at the base.

HALT 847. N. E. ¼, N. E. ¼, S. 31, T. 65-6. Two fragments of a dike rise above water off foot of Mallman's peak, ranging S. 2° W., and about 15 feet in diameter. Slate is seen in contact with it on east and west.

Rock 363. Dike rock from Halt 847 — diabase.

HALT 848. N. E. ¼, N. W. ¼, S. 31, T. 65-6. High cliff of hard slate breaking down in square columnar forms.

HALT 843. S. W. ¼, S. W. ¼, S. 29, T. 65-6. Promontory composed of the rock which I have designated porphyrel. It is quite similar to the rock at Halt 842, in Zeta lake — to be mentioned hereafter. It contains many crystals of feldspar, which lie with their longer axes in same direction. Some of the pieces (individuals) also are rounded, and present the curious property of radial reflections. Some have a definite crystalline form in the centre, with an imperfect crystalline envelope. Some hold a dark mineral, apparently hornblende or chlorite, in the centre. The rock contains also green, chlorite-looking lumps and dark, eight-sided prisms — also some traces of epidote. The rock further includes pebbly forms obscurely isolated and themselves porphyritic.

Rock 360. Porphyrel from Halt 843.

HALT 844. S. W. ¼, S. W. ¼, S. 29, T. 65-6. Head of little bay at foot of Mallman's peak. The rock here is also porphyrel, but the groundmass is more granular and contains disseminated quartz. One large crystal of feldspar is noticed, which contains in the centre an aggregation of small crystals of a dark-greenish mineral. Inclosed in the formation are beds and lenticules of highly-altered slate, and the formation exhibits a rudely-bedded state.

Rock 361. Porphyrel from Halt 844.

HALT 849. N. E. ¼, N. W. ¼, S. 31, T. 65-6. Green crystalline rock with black specks. Probably similar to next, but less bedded.

HALT 850. N. W. ¼, N. W. ¼, S. 31, T. 65-6. Green chloritic schist — uniform in color and composition — distinctly stratified. Strike N. 68° W. Dip vertical.

Rock 364. Chlorite schist.

HALT 851. N. E. ¼, N. E. ¼, S. 36, T. 65-7. A little east of narrows. Porphyritic boss at the angle of north shore. Contains a superabundance of elongated feldspar crystals — a light grayish-green groundmass, some green crystals appearing like hornblende in transformation to mica. Much of the porphyry weathers red-

dish. There is no quartz. I see again a feldspar crystal with a globule of green mineral in the centre. The rock contains frequent subangular fragments of a green rock which itself has an erupted aspect — in fact is exactly like the Ogishke greenstone, found on a mountain south of Campers' island.

Rock 365. Porphyrel from Halt 851.

Back of this bluff is a ridge which is at first heterogeneously porphyritic and unporphyritic — in places a green rock (366) — and then passing toward the summit into hard banded slates.

Rock 366. Green rock in ridge back of Halt 851.

HALT 852. N. E. ¼, N. E. ¼, S. 36, T. 65-6. Here a boss of conglomerate with a green groundmass rises above the surface, and the porphyrel of Halt 851 rests upon it on the east and west, thus:

Fig. 48. Relation of conglomerate and por-phyry at Halt 852, Kekekabic Lake.
It is still possible this porphyry may prove to be stratified.

The greenish rock is the same as Rock 366, in which I did not notice any pebbles.

Rock 367. Chloritic conglomerate.

HALT 853. N. W. ¼, N. E. ¼, S. 36, T. 65-7. Chloritic slates. Dip W. 80°.

HALT 854. N. E. ¼, S. E. ¼, S. 34, T. 65-7 (approximately). Slates appear on the beach.

Back from the beach green schists are again seen, and these are conglomeritic in occasional bands.

Rock 368. Green conglomeritic schist.

The slates on the beach are about the same.

HALT 855. N. W. ¼, S. E. ¼, S. 34, T. 65-7. Slate. Strike N. 52° E. Dip vertical.

HALT 856. N. W. ¼, S. E. ¼, S. 34, T. 65-7. Slate argillitic. Dip about vertical.

HALT 857. N. E. ¼, S. W. ¼, S. 34, T. 65-7. Green bedded rock like that at Halt 854. It also presents a conglomeritic appearance in some of the beds. The dip — if I have not mistaken it — is W. 75°, but there is much uncertainty about it. A few rods west, the dip of the schists seems to be vertical.

Rock 369. Green conglomeritic schist.

HALT 858. N. E. ¼, S. E. ¼, S. 34, T. 65-7. The point just mentioned. The mean attitude of the beds is vertical, and they are curiously eroded by the water — having open arched spaces.

HALT 859. N. E. ¼, S. W. ¼, S. 34, T. 65-7. Rock of same external aspect as last, even to greenish color; but it is hard and dark-gray when broken.

HALT 860. N. W. ¼, N. W. ¼, S. 3, T. 64-7. Fine, dark, silious argillitic schist, but strike and dip indeterminate.

HALT 861. N. W. ¼, N. W. ¼, S. 3, T. 64-7. Fine, dark siliceous argillite, less flinty than at Halt 860. The bedding in a part of the exposure is very distinct and slaty, and gives strike N. 48° W. and dip 50° N. E. There is also a schistosity, which strikes N. 42° E.

HALT 862. S. W. ¼, N. W. ¼, S. 3, T. 64-7. Fine granulitic schist, composed mostly of reddish feldspar and a little quartz with streaks of epidote, and some blotches of dark chloritic rock included.

Rock 370. Fine reddish, granulitic schist.

HALT 863. Ten rods north of 862. Rock intermediate between that of 861 and 862.

Rock 371. Granulitic schist or gneiss, with distinct grains of reddish feldspar and a greenish coloring matter. No mica. Compare with Halts 753, 754 and 755.

HALT 864. N. E. ¼, S. E. ¼, S. 4, T. 64-7. Gabbroloid rock, greenish-gray, weathering very rough — the surfaces looking conglomeritic, but not truly so. Mass of rock consisting of small, grouped, greenish laminæ. Can not determine whether it is feldspathic or chloritic.

Rock 372. Gabbroloid rock.

HALT 865. S. W. ¼, S. W. ¼, S. 3, T. 64-7. Essentially the same as at Halt 864, but not weathering so rough. Has the weathered aspect of gabbro.

Rock 373. Gabbroloid. Is more distinctly crystalline than 372, and more gabbro-like.

HALT 866. S. E. ¼, S. E. ¼, S. 3, T. 64-7. Rock seems composed largely of reddish, granular feldspar, with some quartz. There is also some black mica present, and finally, an undefined greenish constituent.

Rock 374. Gneissic rock.

HALT 867. S. W. ¼, S. W. ¼, S. 2, T. 64-7. Only fragments on shore, but they are all of one kind. Composed of reddish feld-

spar, quartz and a chlorite-like mineral, with some mica. Contains numerous dark-green fragments.

Rock 375. Chloritic geniss.

HALT 868. S. E. ¼, S. W. ¼, S. 2, T. 64-7. Rock composed of red and pale-dun feldspars. Quartz, if present, not detected. Mica wanting and the greenish mineral is wanting.

Rock 376. Subgranular felsite.

§ 28. OGISHKE-MUNCIE LAKE.

From the eastern extremity of Kekekabic to Ogishke-muncie is only a little more than a mile and a half, but the route of travel is about two miles and a half, and passes over seven small lakes and eight short portages. The lakes have been named in succession, Alpha, Beta, Gamma, Delta, Epsilon and Dike lakes, lying in the southwestern part of T. 65-6. Epsilon is the most considerable, having an east and west length of a mile and a quarter; but only the eastern extremity lies in the route. It approaches very near the IVth Arm of Knife Lake, and is connected by a portage. Zeta lake is next in importance, having a length of a mile, and in one part, a breadth half as great. These little lakes are nested in basins of massive conglomerate alternating with hard slates mostly argillitic and graywackenitic.

Ogishke-muncie is a very irregular lake lying mostly in the southern half of T. 65-6. Its main axis trends N. 30° E. and its length is 3½ miles—the whole length of the lake being four miles, and its mean breadth about a third of a mile. In S. E. ¼, S. 23, it is contracted to a sixteenth of a mile. Just west of the narrows is Campers' island, so named from its extensive use for camping purposes. Originally covered with small Norway and Jack pines, these have been almost completely exhausted for fuel.

The features of the land are decidedly bolder than about the western lakes. Ranges of conglomerate obscurely bedded rise on many shores in imposing masses; and these are, on the northwest borders, conspicuously interbedded with vertical sheets of hard argillite. On the north these rocks attain an altitude of a hundred feet. On the south they are succeeded, in the more lofty ranges, a few miles back, by a green formation, here called "greenstone;" and still further back in the highest hills, by an enormous overflow of gabbro.

The country is uninviting to agriculture. Bare, broad, dome-

shaped expanses of conglomerate are separated by narrow tamarack swamps, and the soil-covered slopes are occupied by aspens, which in places certainly have supervened on extensive burnings. The interior was explored on the north and the south to the distance of about two miles, and many careful and deliberate observations were made along all the shores.

HALT 767. N. E. ¼, S. W. ¼, S. 29, T. 65-6. North end of Alpha lake. Rock similar to that at Halt 766, but perhaps weathering a little more slaty. In fact it may probably be styled a silicious and metamorphic argillite.

The portage to Beta lake is about 30 rods.

HALT 768. Near centre S. 29, T. 65-6. Same formation, but more distinctly slaty. Some parts, when broken, are well-characterized argillite. Strike N. 52° E. Dip vertical.

In the bluff near by, the formation weathers into chips by the increase of the slaty matter interposed between the layers of the more silicious and feldspathic matter.

HALT 769. S. E. ¼, N. E. ¼, S. 29, T. 65-6. Graywackenitic slate, intersected by veins of quartz and of chloritic material.

HALT 770. S. E. ¼, N. E. ¼, S. 29, T. 65-6. Portage to Gamma lake. Rock very similar to that at Halt 766. Very distinct alternating bands, more and less slaty. Strike N. 34° E., sinuous. Dip vertical.

This portage is 20 rods long, but rough and difficult.

HALT 771. S. E. ¼, N. E. ¼, S. 29, T. 65-6. Portage to Delta lake. The rock continues as at Halt 766 — a graywackenitic slate, hard, compact, jointed, but distinctly bedded.

HALT 772. N. W. ¼, N. W. ¼, S. 28, T. 65-6. Graywackenitic argillite, with some of the beds quite perfectly a slate, and others granular.

Rock 314. Argillite from Halt 772.

HALT 773. S. E. ¼, S. W. ¼, S. 21, T. 65-6. Portage out of Delta lake. Fine hard argillite, rather slaty. I find some good for whetstones. Strike N. 14° E. Dip N. 75°.

HALT 774. N. E. ¼, N. W. ¼, S. 28, T. 65-6. Portage out of Epsilon lake. Slates similar to the recent observations.

HALT 775. Centre S. 28, T. 65-6. Porphyry, extending for at least four rods along the beach. An earthy green base tolerably compact, filled with whitish feldspar crystals.

Rock 315. Porphry. (Porphyrel.)

HALT 776. Six rods north of Halt 775. A dark rock apparently eruptive — but probably not completely so — lying at wa-

ter's surface, and rising five feet above, having a decidedly diabasic look. It rises in a vertical wall.

Above this, porphyry, some with reddish feldspar. It seems to have overflowed the diabase—assuming the structure of nearly horizontal beds. But still I can not be certain that this is an overflow. Further on, the porphyry comes down to the water's edge.

Rock 316. Porphyry with reddish feldspar.

Rock 317. Diabase? under porphyry.

HALT 842. S.W. ¼, N.E. ¼, S. 28, T. 65-6. Zeta lake, north side of narrows, near Halt 776. Here is a porphyry-like rock having, like that at Halt 776, all the general appearance of an ordinary porphyry. Nevertheless, it contains traces of foreign fragments. The base is not completely homogeneous. Here especially can be seen hornblende somewhat extensively disseminated.

Rock 359. Porphyry-like rock.

A careful study of the rock under the lens shows that it is crystalline, with a fine, dark-green base or groundmass. Moreover, the rock seems to be rather the groundmass simply of the conglomerate of the region—that is, an aspect of the wide-spread Ogishke Conglomerate. This groundmass *may* differ in some important respect from the groundmass of the conglomerate north of Campers' island, which, undoubtedly, is a bedded rock, and, in all probability, a sedimentary rock, though highly metamorphosed; still, I do not discover as yet any important differences. I incline to think both rocks frgamental primordially, and the porphyritic characters here and elsewhere seen, as superinduced by metamorphism, secondarily. I see no objection to regarding some of the feldspar fragments as sedimentary, and the quartz grains as largely so; but this does not preclude the porphyritization of portions of the rock adapted to that change.

According to my view this rock was not originally molten. It is not an eruptive rock. It is not, therefore, a typical porphyry. It bears obscure marks of sedimentation—even of conglomeritic accumulation; yet it is distinctly and typically porphyritic. It is not a porphyritic conglomerate, for the conglomeritic character is the least observable feature. It is not a purely sedimentary accumulation of individuals of feldspar in a primitive mud, for too many of the crystals retain their angles unimpared. We need again some new designation, and I will, at least provisionally, use the following:

PORPHYREL — A diminutive of porphyry. A rock having a porphyritic aspect, but without a homogeneous, feldspathic base — not primitively erupted, like porphyry, but originally sedimentary, or, at least, igneo-aqueous in origin, and secondarily, subjected to powerful metasomatic action, involving especially feldspar-development.

I incline to the opinion that nearly or quite all the "porphyry" associated with the schists and conglomerates of this region possess the character of porphyrel.

HALT 777. N. E. ¼, S. E. ¼, S. 28, T. 65-6. Entrance to Dike lake. Slate, dark slate color, compact but argillitic. Strike N. 17° E. Dip vertical. Back from the beach rises a hill composed of conglomerate. The pebbles consist of granite, diabase, flint and a greenish aphanitic rock; and there is a groundmass of diabasic or graywackenitic material. In parts of the conglomerate are disseminated grains of glassy quartz, giving the rock a porphyritic appearance; and on the weathered surfaces, white feldspathic grains come into view, strengthening the porphyritic indications. The feldspar can also be seen in some fresh fractures as ill-defined nuclei.

Rock 318. Conglomerate from Halt 777.

Rock 319. Porphyritic conglomerate.

The different portions of the conglomerate are readily scratched with the knife. The pebbles are mostly with rounded angles. Some attain a diameter of ten inches. Some are themselves porphyritic with quartz.

The weathered surface everywhere exhibits what I feel constrained to regard as *flowage lines*. Fibres and sheets are wrapped around the pebbles. The longer axes of the pebbles do not lie in any fixed direction. I can not detect any general bedding planes, though joints intersect the formation chiefly in two directions, N. 48° W. and N. 11° W. There is also a tendency to rude horizontal bedding.

Proceeding to the summit of this hill, I find some indications of bedding which strike N. 42° E. and dip south 80°.

The pebbles are arranged in courses alternating with belts containing much smaller pebbles. These bands are many times repeated.

Some of the groundmass has every appearance of diabase, quite like that under the porphyry at Halt 776.

Rock 320. Diabasic groundmass of conglomerate.

Some of the pebbles are themselves porphyry, resembling the porphyrel at Halt 777.

The contact between the slate and conglomerate is not abrupt, but by steps, somewhat as shown by the following figure:

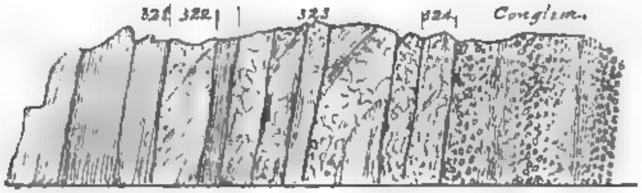

Fig. 49. Contact of slate and conglomerate at Halt 777, Dike Lake

The numbers refer to the rock-series of the Report.

The view is taken looking southeast. The strike is N. 22° E. On the north is the characteristic slate (321). Next, slate mixed with porphyritic material. (In 322 it is granitic.) Then a graywackenitic mass with often faint outlines of pebbles (323). Next, more distinct pebbly outlines with still some slate (324). Lastly the well-developed conglomerate.

Rock 321. Slaty, micaceous argillite.

Rock 322. Slate and granular rock.

Rock 323. Slate with outlines of pebbles.

Rock 324. Black, silicious argillite. Halt 778.

HALT 778. N. W. ¼, S. W. ¼, S. 27, T. 65-6. Portage from Dike lake. Dark slates standing vertically. Strike N. 30° E. Dip N. 85°.

HALT 787. S. E. ¼, S. W. ¼, S. 27, T. 65-6. Ogishke-muncie lake. Slate. Dip S. 65°.

HALT 788. S. W. ¼, S. E. ¼, S. 27, T. 65-6. Conglomerate, but having a different aspect from that on north shore. The groundmass is a brighter green. Many of the pebbles are of similar material. The pebbles are more angular and less distinctly defined.

HALT 789. N. W. ¼, S. E. ¼, S. 27, T. 65-6. Conglomerate like that at Halt 788.

HALT 790. N. E. ¼, S. E. ¼, S. 27, T. 65-6. Almost a strict diabase, but in portions containing rounded pebbles, mostly not very distinctly isolated. The rock seems to be a superfluous supply of groundmass.

HALT 791. N. E. ¼, S. E. ¼, S. 27, T. 65-6. Same as at Halt 790.

HALT 792. N. W. ¼, S. W. ¼, S. 26, T. 65 6. Conglomerate with rounded pebbles, the whole rock having a diabasic aspect.

HALT 793. S. W. ¼, N. W. ¼, S. 26, T. 65-6. Rock looking like a mass of greenstone — breaks and weathers like it — but the outlines of pebbles can be traced in many places, and there are lines of bedding obscurely visible. It is truly diabasic in outer appearance, but seems to have resulted from the softening of a conglomerate.

HALT 794. S. E. ¼, N. W ¼, S 26, T. 65-6. Diabasic conglomerate still. Plenty of large rounded pebbles traceable on weathered surfaces.

HALT 795. N. E. ¼, S. W. ¼, S. 26, T. 65-6. Black slate much crumpled and baked. Strike N. 22° E. Dip S. 80°.

HALT 811. N. E. ¼, S. W. ¼, S. 26, T. 65 6. Across the rapids from 795. Much altered, dark argillites appearing in the bluff—the continuation of those at Halt 795. They are here intersected by an abrupt transition to rock which appears to be erupted.

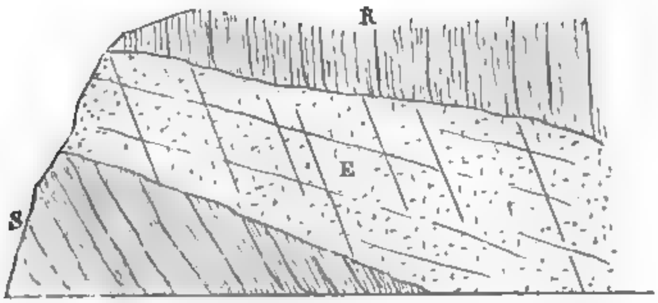

Fig. 50. Appearance of a dike, Halt 811, Ogishke-muncie Lake.

S, slate; E, supposed dike; R, slate from vicinity with same strike as S, but different dip. Figure partly theoretical.

The above is a view of the face of the bluff somewhat in perspective. S represents the slates striking N. 52° W, and dipping N. E. E is the eruptive rock, cutting off the strata of S as if it were a dike. On the top of the hill, four or five rods from S, the slate reappears with a strike N. 37° E. The above cut represents nearly a horizontal projection of the exposure. The

natural inference is that this eruptive rock is a dike. That it has locally disturbed the strata is shown by the evident discorddance of S and R, and also by the fact that the shales two or three rods further west, have a strike N. 28° E, with a dip rather south of east, which is about normal and agrees with the observations at Halt 795.

Rock 339. Eruptive rock, Halt 811.

Rock 340. Slate, Halt 811.

HALT 796. S. E. ¼, N. W. ¼, S. 26, T. 65-6. Little island. Sericitic schist, very ferruginous and quite chloritic.

HALT 797. N. W. ¼, N. E. ¼, S. 26, T. 65-6. Diabasic conglomerate.

HALT 798. S. W. ¼, S. E. ¼, S. 23, T. 65-6. Sericitic schist again, but it graduates by nameless transitions into the prevailing diabasic conglomerate.

This completes the proof that the slates and conglomerate belong to one formation, and that they are a prolongation from Vermilion lake.

Rock 326. Diabasic groundmass from Halt 786.

Rock 327. Interlaminations of slate and groundmass, Halt 786.

Rock 328. Green diabasic groundmass, Halt 788.

Rock 329. Diabasic groundmass from Halt 790.

Rock 330. Sericitic schist from Halt 796.

Rock 331. Sericitic, chloritic schist from Halt 798.

Rock 332. Sericitic, first, gradation toward diabase.

Rock 333. Sericitic, second, gradation toward diabase.

Rock 334. Sericitic, third, gradation toward diabase—the change complete.

The specimens 331-334 were collected within four feet of each other. There is a point of a hill which at the extremity is sericitic, but this for a thickness of three feet only. The rock crumbles to chips and resembles in every way the sericitic schists seen at Vermilion lake. Just back, and at a higher level, the rock is more solid. A little further back it is still more solid, and looks much like a massive chlorite rock (333). Finally, the well-marked groundmass rock appears and constitutes the bulk of the exposure (334).

HALT 779. S. E. ¼, S. W. ¼, S. 23, T. 65-6. CAMPERS' ISLAND. Conglomerate.

HALT 780. N. E. ¼, S. W. ¼, S. 23, T. 65-6. Opposite Campers' island, north side. Conglomerate, but very extraordinary.

The formation is cut up by joints, as if an erupted rock. Groundmass is the principal part. It is composed of two varieties of feldspar and considerable quartz in disseminated grains.

Ascending to the summit of this cliff I find evidences of bedding, and I think they are unmistakable. They consist in the alternating arrangement of the materials. They show a Dip S. 65° and a strike N. 42° E. Toward the top the pebbles are more abundant and more isolated from the matrix, but this can hardly have any significance. In some beds they lie as thick almost as possible.

HALT 781. S. E. ¼, S. W. ¼, S. 23, T. 65 6. Conglomerate not notably different from that at Halt 780. This, however, is much broken down, forming a massive talus.

HALT 782. N. W. ¼, N. W. ¼, S. 26, T. 65-6. Dark argillite, well characterized. Strike N. 47° E. Dip nearly vertical.

On the northwest occurs the conglomerate. The slate in the vicinity for two or three rods is a little more rough. The junction is perfectly abrupt, and continues on an almost rigidly straight line from the shore for ten rods back. On the surface, the appearance is like this:

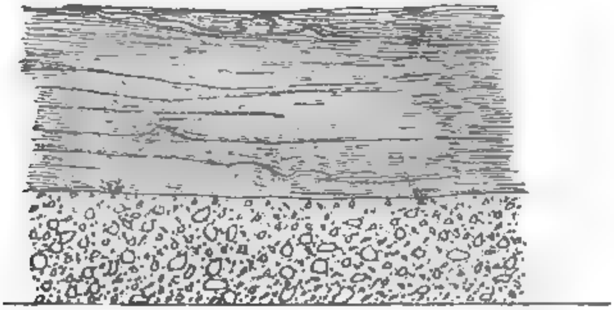

Fig. 51. Junction of slate and conglomerate Halt 782, Ogishke-muncie Lake.
Looking N. 43° W.

On the west side of this headland occurs again the junction between the slate and conglomerate. The island in the narrows to the little bay is conglomerate.

HALT 783. N. W. ¼, N. E. ¼, S. 27, T. 65-6. Conglomerate. Contains a good amount of red and banded jasper.

HALT 784. N. W. ¼, N. E. ¼, S. 27, T. 65-6. Conglomerate.

HALT 785. S. E. ¼, N. W. ¼, S. 27, T. 65-6. Conglomerate.

In courses, the pebbles are very abundant, but much of the rock is a massive diabase-like material, having the aspect of a huge dike; but the pebble-courses run directly through it, with a dip S. 80°.

The dips in this vicinity are such that the schist-beds assume a position above the conglomerate, and hence, in the absence of inversions, would be newer.

HALT 786. S. W. ¼, N. W. ¼, S. 27, T. 65-6. Slate and conglomerate. On the shore the rock is chiefly the groundmass of the conglomerate. Then succeed slates—then well-marked conglomerate. The groundmass rock contains a few obscure pebbles.

This occurrence of slate being further north than some observed conglomerate, a recurrence is indicated. It is very evident, however, that beds of slate and conglomerate exist in numerous alternations.

This completes the circuit of the lake. I now present the results of some observation made on excursions to the north and south of the lake in the vicinity of Campers' island.

From this island, looking southward, a range of hills is seen which may be estimated at 300 feet high. The route pursued started from the head of the little bay, Halt 795.

HALT 799. About ten rods back from the point. The slate is almost flinty. Side by side with it are beds of a diabasic-looking schist.

HALT 800. 20 rods back. Strike N. 20° E. Highly baked argillite. Dip vertical.

HALT 801. 30 rods back. Highly baked argillite, and side by side with it, showing bedding. a slate porphyritic with feldspar and glassy grains.

Rock 335. Porphyritic schist from Halt 801.

HALT 802. About a half mile back. Contorted slates, dipping 60° E. with a strike N. 33° W.

HALT 803. On the lower shoulder of the mountain. Bedded, highly metamorphic slates continuing in alternation. Strike N. 12° E. Dip S. E. 80°. Adjoining this on the south the schists are a little sericitic and crumbling to chips.

HALT 804. Northern slope of valley following Halt 803. Same rock, with Strike N. 23° W., undulating. The strike of the ridge is N. 32° E., and the previous ridges have a similar strike, and this is nearly the prevailing strike of the formation. This rock is somewhat more flinty than the preceding.

HALT 805. Beginning of second from last ascent. Similar schist, but with strike N. 78° W. Dip vertical. Beds much contorted. Close by, the dip is westerly 45°. These irregularities show marked disturbance.

HALT 806. First ridge north of assumed summit. Strike of schists N. 67° W. Dip 45° westerly.

HALT 807. Ridge next the summit. Strike much broken up. Here are great masses of conglomerate with doleritic ground-mass.

HALT 808. On the last ascent. The altered slates are seen in contact with a green doleritic rock itself containing pebbles. The slates strike N. 68° W., with a dip N. 50°. The relations are shown in the following figure:

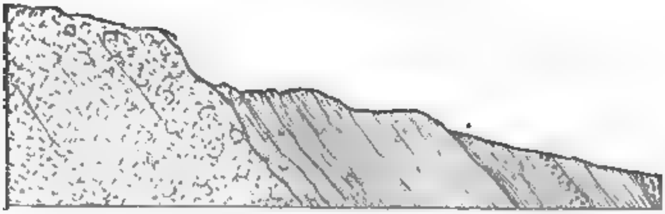

Fig. 52. Relations of the "green rock" and slates south of Ogishke-muncie Lake.
Looking West.

Rock 336. Green rock.

HALT 809. At the summit. The green rock is more clearly developed. It is composed of grouped lamallæ of a greenish color and rather soft. This appears much like chlorite. Even this rock contains pebbles to a limited extent. Some are diabasic and some flinty.

Rock 337. Green rock from the summit.

This hill is made, by aneroid, 240 feet above the lake. But half a mile further south a hill appears which seems to be as much as 100 feet higher.

HALT 810. A few rods east of Halt 801. Outcrop of porphyritic rock near Fox lake. [See Halt 811, after 795.]

Rock 338. Porphyritic rock. Halt 810.

The following are localities on a tour to the high hill northwest of Campers' island:

HALT 812. One-quarter mile north of north shore. The usual conglomerate.

HALT 813. One mile north of lake. A knob of the conglomerate appears porphyritic, but it contains grains of red jasper and of flint and quartz, besides crystals and grains of feldspar; and it may probably be regarded a compacted mass of gravel derived mainly from the disintegration of granite. It contains also a few grains and small pebbles of carbonaceous slate. On the whole, it is only a finer condition of the conglomerate. There is a little matrix material of a greenish color, which appears composed largely of smaller grains of the same. What else there is to give a greenish color, the compound microscope must reveal.

HALT 814. 1¾ miles from lake. As we go north the conglomerate contains less matrix, being distinctly and simply a conglomerate. In places also it contains more jasper.

HALT 815. ½ mile east of mountain. Strike N. 47° E.

HALT 816. Summit east of mountain. All slate. The last seen of conglomerate is one-fourth mile southeast of here. The dip is vertical. Strike N. 37° E. Mountain visited on the south side bears S. 38° E.

Proceeding W. N. W. the formation becomes conglomeritic again; but it is not a coarse conglomerate.

HALT 817. Making the last ascent. Greenstone apparently well marked, having black specks. It joins on the east beds of conglomerate and slate. In fact it does the same on the northwest, and in spite of appearance, I surmise this is merely an altered sedimentary rock.

HALT 818. At the summit. Highly altered slates and greenstone-like rock.

The following are bearings from the summit:

Mountain visited on the south side (observation probably erroneous).

East Twin mountain..S. 8° E.
West Twin mountain..S. 2° W.
North end of nearest little lake..........................S. 43° E.

From a point twenty rods west of summit:

Mallman's peak...... ....S. 42° W.
East Twin mountain..S. 9° E.

HALT 819. 20 rods west of summit. At this place are laminated, dark-gray, highly silicious argillites. Dip vertical. Strike N. 40° E.

Rock 341. Porphyry-like, but gravelly matrix. Halt 813.

Rock 342. Greenstone conglomerate. Halt 817.

Rock 343. Porphyry pebble in porphyry matrix.

Rock 344. Porphyritic matrix.
Rock 345. Gravelly matrix.
Rock 346. Greenstone (like 342) columnar.

§ 29. GABIMICHIGAMA LAKE.

An irregular lake lying on the four corners of the townships 64 and 65 of ranges 5 and 6. Its main axis trends N. 35° E, and has a length of three miles. The mean breadth is three-fourths of a mile. The water is deep and the shores are bold and even mountainous — especially around the southern half of the lake. The geology is interesting and in some respects peculiar. The middle of the west shore lies upon massive graywacke, but the southern portion reaches into the gabbro region, without doubt a continuation of the range occurring two or three miles south of Ogishke-muncie lake. Titaniferous iron ore is found in abundance.

HALT 820. S. W. ¼, S. E. ¼, S. 26, T. 65-6. The approach to Gabimichigama lake from Ogishke-muncie is through Fox and Agamok lakes, and over the portages around the rapids connecting these small lakes. The whole distance in a straight line is is about two miles; but the portages are little used, and the country is very broken and difficult. The scenery along the water course presents bold features; and one or two wild waterfalls plunge through deep and dim-lighted chasms in the dark silicious argillites.

HALT 820. S. W. ¼, S. E. ¼, S. 26, T. 65-6. Silicious slate. Stream from Gabimichigama passed by a cascade 25 feet high, through a gorge with walls on the east 50 feet high and on the west 40 feet. Strike N. 37° E. Dip vertical. The rock is dark but exceedingly hard; breaks into large cuboidal blocks. It is almost black, and not conglomeritic.

HALT 821. S. W. ¼, S. E. ¼, S. 26, T. 65-6. Outlet of Fox lake. Dark, silicious slate, with contorted lamination. Genera strike N. 78° W. Dip S. 50°.

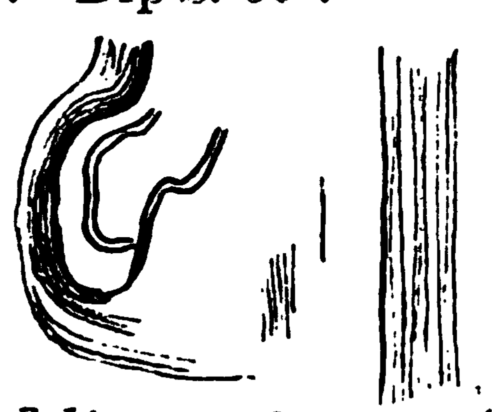

Fig. 53. Folding of schists, Halt 821, Fox Lake

The schists of northern Minnesota have held a persistent strike so far, and with so little contortion, that the presence of these disturbances here indicates the proximity of the dynamic centre.

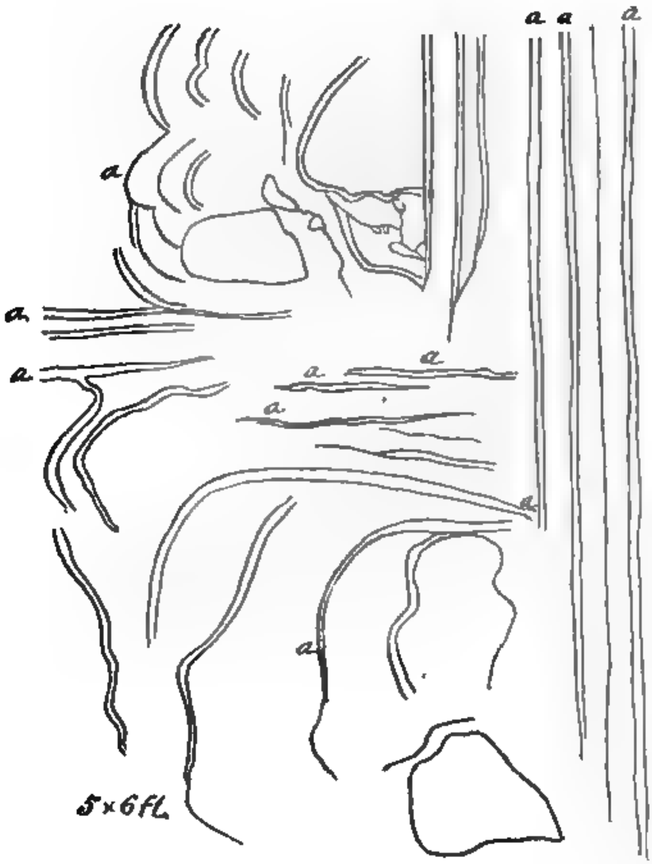

Fig. 54. Another example of plication at Halt 821, Fox Lake.
a, a, a, bands which bleach white and remain salient The intervening spaces are darker and depressed.

HALT 822. S. W. ¼, S. W. ¼, S. 25, T. 65-6. Dark silicious slates. Strike N. 87° E. Dip S. 85°.

HALT 823. S. W. ¼, S. W. ¼, S. 25, T. 65-6. Portage out of Fox lake. Slate, very silicious. A few rods back, the rock appears to be erupted — granular-gray.

Rock 347. Erupted rock near Halt 823.

A few rods southeast, the erupted rock suddenly terminates, and silicious slates recur with strike N. 68° W. and dip S. 78° Four rods further southeast are slates uncontorted, having strike N. 82° E. and dip vertical.

Immediately contiguous are laminæ in two courses, which are much convoluted, presenting the appearance of arabesque. The salient laminæ are dark and much like the impressed parts but more cherty.

HALT 824. S. W. ¼, S. W. ¼, S. 25, T. 65-6. Middle of portage to Agamok lake. Silicious slate. Strike N. 82° E. Dip S. 85°.

Rock 348. Flinty slate from Halt 824.

HALT 825. S. W. ¼, S. W. ¼, S. 25, T. 65-6. Across ravine by angle of little lake. Silicious argillite, much broken up.

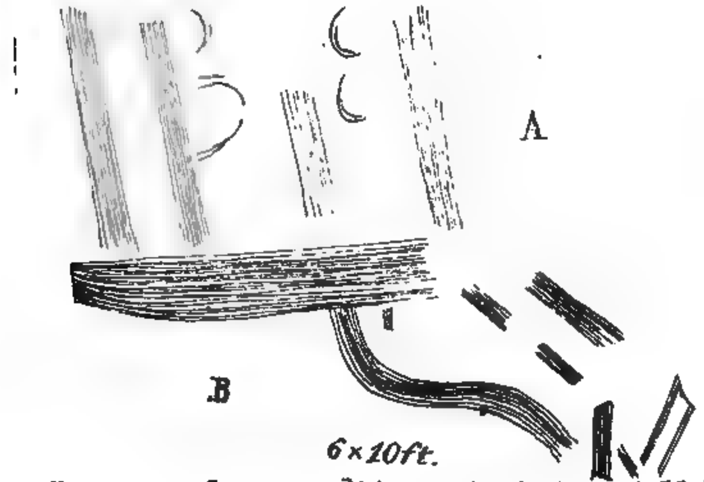

Fig.55. Broken condition of slates at Halt 825, Agamok Lake.
A, imperfectly bedded. B, not bedded.

Eight rods further southeast, is a band of highly ferruginous slate two feet wide, reminding one of the iron jaspilite further west.

HALT 826. N. W. ¼, N. W. ¼, S. 36, T. 65-6. Near outlet of Agamok lake. Silicious schists, partly dark and argillitic, and partly gray and granular.

HALT 826 *bis*. N. W. ¼, N. W. ¼, S. 36, T. 65-6. Near western termination of Agamok lake. Rock bedded, granular.

HALT 827. Near western constriction of Agamok lake. Rock bedded but gray, granular, with black specks, highly silicious, bedding obscure.

Rock 349. Graywacke-like, as above.

HALT 828. S. E. ¼, N. E. ¼, S. 36, T. 65-6. Narrows of Agamok lake. Same graywacke-like rock as at Halt 827.

HALT 829. S. E. ¼, S. E. ¼, S. 36, T. 65-6. Gabimichigama lake, at outlet. Gray rock looking a little like muscovado gabbro, but it is bedded distinctly.

Rock 350. Muscovado gabbro? — but much like Rock 349.

HALT 830. S. E. ¼, S. E. ¼, S. 30, T. 65-6. Graywacke-like as before. No bedding certainly discernable, but it seems quite confused.

HALT 831. N. E. ¼, N. W. ¼, S. 1, T. 64-6. Graywacke-like, but darker and more crystalline. Not stratified as far as seen, but lies in rough, irregular, horizontal beds in the hill, to the height of forty feet.

Rock 351. Graywacke-like, Halt 831.

HALT 832. S. E. ¼, N. W. ¼, S. 1, T. 64-6. Graywacke-like. Bedding obscure. Strike seems to be N. 56° W. with dip S. 85°. Still, the continuation of same bluff shows only rough horizontal bedding. Fine glistening particles are present.

HALT 833. S. E. ¼, N. W. ¼, S. 1, T. 64-6. Still graywacke-like, but a little darker. This bluff is also rudely bedded horizontally.

HALT 834. S. E. ¼, S. W. ¼, S. 1, T. 64-6. West arm of southern bay of the lake. The rock to six feet above water is a bluish, graywackenitic mass, with augite or hornblende scarcely present. It appears to be essentially sedimentary, with lines of bedding striking N. 68° W, and vertical dip; but the rock on the whole has a very massive aspect.

Rock 352. Massive graywacke. Halt 834.

Above this is an unstratified mass, consisting, with much dark mica, of waxy feldspar so glassy that I am not certain that it is not quartz. This rests on the edges of the first.

Rock 353. Micaceous gabbrolite?— three specimens.

This seems preparatory to gabbro.

HALT 835. N. W. ¼, N. W. ¼, S. 12, T. 64-6. Gabbro of medium texture and apparently some mica scales.

Rock 354. Gabbro — two specimens.

HALT 836. N. E. ¼, N. W. ¼, S. 12, T. 64-6. Entrance to last little arm of southern bay. Gabbro.

Rock 355. Gabbro from Halt 836.

HALT 837. N. E. ¼, N. W. ¼, S. 12, T. 64-6. Opposite Halt 836. Gabbro, a little resinous in color.

HALT 838. Centre S. E. ¼, S. 1, T. 64-6. In the narrows, east side. High cliff, roughly bedded, with beds dipping away from shore eastward at an angle of 45°, suggesting that the bedding seen at Halt 831 and other points, may be a real sedimentary structure. This rock, in part, presents much the appearance of gabbro.

Rock 356. Gabbrolite from Halt 838.

Some of the beds are heavily charged with iron, apparently titaniferous, and have a dark granular aspect. The cliff here rises seventy feet high.

Rock 357. Band of iron-bearing rock.

HALT 839. N. E. ¼, S. E. ¼, S. 1, T. 64-6, Muscovado gabbro, fine, resinous, bedded, with dip eastward 40°.

HALT 840. S. W. ¼, N. W. ¼, S. 6, T. 64-5. A remarkable headland. Some forty feet perpendicular. The whole exterior presents a rusted appearance, and is crumbling away. It seems to be rudely bedded almost horizontally, but with a small eastward dip. The rock is heavy, and seems to be composed largely of carbonate of iron? Apparently there is also considerable hornblende or augite and mica. In crossing the promontory, the sheets of rock outcrop and overlap like successive outflows of molten matter.

Rock 358. Sideritic? rock from Halt 840.

HALT 841. Centre N. W. ¼, S. 6, T. 64-5. Island. Coarse gabbro poured over a huge pile of coarse, angular fragments of muscovado. An interesting observation, for the muscovado is stratified. The interstices among the fragments of it are filled so completely as to demonstrate the original fluid character of the gabbro.

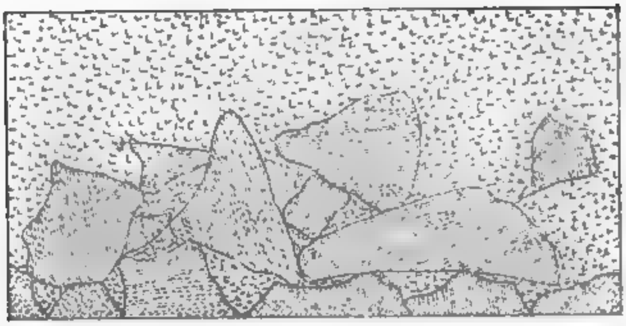

Fig. 56. Gabbro on "muscovado" fragments, Hall 841., Gabimichigama Lake.

Gabbro was seen in a high characteristic outcrop on the extreme southeastern shore beyond the large island, but the rough condition of the water rendered it impracticable to land.

§ 30. SUMMARY OF OBSERVATIONS.

The foregoing is a particularized exposition of observations made within the region indicated. For convenience of cursory readers, I offer here a condensed general statement of the facts.

General Condition of the Rocks. — The region so far as traversed, presents geologically a series of schists flanked on the north and south by massive crystalline rocks. In the western part, these are gneissic on both sides. In the eastern part, the schists extend north beyond the limits of the field, and on the south, the gneissic rocks are replaced by gabbro and greenstone. The schists and the bedded crystallines stand in a nearly vertical attitude, and have a strike which is east-northeast in the western part of the region, and northeast or north-northeast, in the eastern part. The strike is remarkably persistent and uniform. Seldom are flexures in the alignment noticed until we reach the Ogishke-muncie and Gabimichigama. A similar statement may be made of the dip. It oscillates from eighty degrees northward to eighty degrees southward. Very rarely do we find the dip varying over ten degrees from the vertical. What variations exist are not prevailingly northward nor southward. It appears that the normal attitude is vertical, and it is not at present possible to state which deviation from this is the result of inversion.

Nature of the Schists.— Mineralogically, the schists embrace

sericitic schist, chlorite schist, argillites, graywacke schist, mica schist and hornblende schist. Very commonly the mineral character is mixed — the chloritic constituent being present in sericitic schists and argillites, and the argillitic character often remaining in sericitic schists. Not unfrequently, the sericitic schists have to be qualified as both chloritic and argillitic. The mica and hornblende schists are generally exempt from chloritic intermixture. though, as will be stated, many gneissic rocks abound in a chloritic constituent — probably the result of alteration.

In the western part of the district. sericitic schists predominate; and they are mostly confined to the western and middle parts — that is, to the region of Vermilion, Eagle Nest, Long, Fall, Newfound and Moose lakes. In the eastern part of the district, argillites predominate, and they are mostly dark colored and widely silicious. They prevail especially in the regions of Knife, Pseudo-messer, and Sucker lakes, but argillitic schists often appear, more or less mixed, through the whole extent of the region, and a small area of sericitic schists was found on the shore of Kekekabic lake.

Well-developed mica and hornblende schists are not very common, but they exist along the belt of approximation between the crystallines and the earthy schists. This will be further explained.

In structure the earthy schists present every conceivable variation. To a large extent they are compact, hard and not readily cleavable, though the principal foliation almost always coincides with the planes of sedimentation. From the hard and unfissile state they graduate to characteristic shales, and thence to the most thinly laminated phyllites.

Graywacke.— A very conspicuous feature of the schist belt is the frequent and often abrupt transition from a pronounced slaty structure to a massive structure, in which the bedding planes are obscure, and in many cases scarcely discoverable. These massive conditions present the ordinary external appearance of diabase, and sometimes of dolerite; and it requires many observations to convince one's self that none of these are truly eruptive. At times these masses are found cut up by joints into cuneiform cuboids, ringing and flinty, precisely like rocks of eruptive origin; and if one were to restrict his observations to a few such occurrences, he would feel persuaded that large portions of the region are occupied by true dikes of enormous extent. But

with surprising abruptness these rock-masses are seen assuming a more earthy charactér and losing their eruptive features. Close by, the lines of an ancient stratification come into view, and these always conform in position to the rule of the region. The rock may now be seen more distinctly to contain an important quartzose constituent. This is sometimes in fine, almost indefinable grains and sometimes a silicious groundmass. A different condition of the rock contains, with more or less quartz, a considerable feldspar — mostly orthoclase, but partly triclinic. This appears sometimes in distinguishable grains imbedded in the silicious or silico argillaceous groundmass, and sometimes as a feldspathic groundmass holding obscure grains of quartz. Not unfrequently the groundmass appears to be a real petrosilex. In all cases the rock possesses great hardness and toughness. These are the macroscopic characters of a range of rocks which I have called graywacke. Many times an intermediate condition is found—the sericitic or argillitic or chloritic character appearing progressively and increasingly in the sub-massive rock. I have then described the rock as graywackenitic.

Though this group of rock-varities does not present the typical aspect of graywacke, especially in its predominantly massive con. ditions, it seems to approach nearest that rock as described by recent writers of authority.

Arrangement of the Schists.—In the western portion of the region, the central part of the schist-belt is occupied by strata predominantly sericitic. With these are associated hæmatitic, magnetitic and ferruginous jaspilitic beds and bands. The sericitic belt passes from the southeastern shores of Vermilion lake. It covers the greater part of T. 64-14, including Eagle Nest, Gem, Sand, Nameless and Mud lakes. It is supposed to cover the northern part, at least, of T. 63-12. It embraces the southeastern corner of T. 63-13. In T. 63-12 it embraces all of Long lake except the northwestern bay, and covers, apparently, all the southeastern part of the town. The greater part of Fall lake in T. 63-11, is in sericitic schists, and they extend south to include part of the northern shore of Garden lake, and north far enough to embrace Newton lake in T. 64.11. In T. 64-10, the sericitic schists have been seen only on Urn lake, but probably they occupy most of the southern half of the township, They extend in a broad sweep diagonally through T. 64-9, including Moose and Newfound lakes. Entering T. 64-8, in a broad belt on the west side, they cover the region of En-

sign lake, and in the eastern part of the township wedge out. Further east sericitic schists are exceptional.

Considering more precisely the distribution of the various species of schists, it may be said, in a general way, that the more chloritic schists lie on the north and south of the central line of the sericitic schists, forming two broken belts; but they often occur in the midst of the sericitic belt, and in parts of the region they are comparatively wanting. Generally speaking, the argillites are somewhat clearly restricted to belts still more removed from the main axis of the sericitic schists. They under go a large development toward the east and in large part usurp the place of the sericitic schists; while westward the latter quite frequently retain a character somewhat argillitic.

Still outside of the predominant argillites, both on the north and the south, are those forms of clastic rocks which I have styled graywacke. Wherever a section is made across the sericitic belt, graywacke is pretty certain to be met along the outer border, but there is no regular and continuous belt of it. The schists pass by gradations along the strike, into graywacke, and the latter passes again into schists.

More distinctly limited to marginal belts are the crystalline schists, mica schist, hornblende schist and diorite schist. On the north side the schists are first seen in the northeast corner of the unsurveyed T. 63-14. They occupy most of the south shore and the southern islands of Burntside lake. They probably form a narrow belt through T. 63-12, but they have not been seen. They are scarcely known in range 11. They have a small development through the centre of T 64-10; but east of that their place is beyond the national boundary.

On the south, these schists make a distinct development in T. 63-11, north of Farm and Friday lakes. Further east, their place is between Snowbank and Ensign lakes, but they have not been seen.

It is apparent that the distribution of the earthy schists sustains little correspondence with the planes of bedding. Everywhere the strike of these planes presents a remarkable uniformity and regularity. But when we attempt to trace a bounding line between the sericitic schists and the chloritic, or between the sericitico-chloritic and the argillites, we find it exceedingly irregular, crossing the lines of strike in one direction and the other. A geological map which should delineate the geographical limits of the earthy schists would assign different colors to

strata of the same age. It becomes apparent that the sericitic, chloritic and argillitic schists are only different states of the same formation. It is pretty certain that the graywacke is only another state of the same, though the graywackenitic alteration has most frequently taken place on the outer verge of the belt of earthy schists.

Finally, it must be said that the indications of a genetic connection between graywacke and the mica schists are very noteworthy. A visible gradation from one to the other has been noted in numerous instances. Still, I think the crystalline schists may be assigned to special areas on the geological map.

Nature of the Gneissic Crystallines.—In the regions remote from the neighborhood of the schists, the gneissic crystallines incline to a characteristic granular structure—the mineral individuals appearing to belong to the order of first consolidation. In other regions, they vary to indistinctly granular, to obscurely granular with more or less of a groundmass, and to a rock consisting of a groundmass variegated by ill-defined blotches, sometimes mixed with distinct mica or hornblende. These forms belong chiefly to the order of second consolidation—following the view of Fouqué and Michel-Lévy.

On the south of the main schistic belt, the gneissic crystallines are composed chiefly of quartz. orthoclase and hornblende. At many localities these individuals are beautifully developed, well-defined and of large size. Especially do we find the hornblende individuals large, bright and black. Sometimes instead, the orthoclase gives us a finely porphyritic crystalline. At other points the quartz is almost completely wanting, and a fine hyposyenitic rock prevails. These crystallines were seen especially around the shores of White Iron lake.

On the north side the crystallines are composed chiefly of quartz, orthoclase, mica and hornblende. Around Burntside lake, hornblende is little seen, and the crystalline is a true gneiss. In many cases, the constituents are well-defined, in others, the mica is changed to hydromica. Occasionally, hornblende is seen associated with mica, and in this case the mica is generally biotite and in good condition. Along the shores of Basswood lake, biotite is often associated with hornblende; but in the most northwestern regions visited, hornblende prevails almost exclusively. Very extensively distributed is a crystalline rock composed of orthoclase and chlorite, or orthoclase, quartz and chlorite. It sometimes contains a little hornblende,

and sometimes nenaccanite is present. The chlorite and feldspar are much blended together, without definite lines of contact. The rock is not distinctly described by authors, but I have designated it chlorite gneiss, whether containing quartz or not. It has been seen most frequently along the IVth Arm of Basswood lake, and in the southern part of Kekekabic.

This rock must have a very large development about Lake Superior, for I find many boulders composed of it distributed over southeastern Michigan.

Very often I find the dark mineral almost or quite wanting, and the rock becomes what I have designated a granulite. This condition, however, seems to be merely local and of little significance.

In a few localities, I have been induced to think the feldspathic constituent in the quartzless crystallines was plagioclase. I have therefore quoted diorite as belonging to the same category as the gneissic forms. More frequently, however, diorite, like diabase, has been seen as a dike. Not improbably some of the supposed hornblende, is truly augite; but I have not ventured to announce any augitic crystallines.

Areas of Gneissic Crystallines.—The gneissic crystallines occur in two separated areas. One of these is on the north of the schistic belt and the other on the south. The northern area is first encountered on the islands and along the north shore of Burntside lake. It has been traced along two lines beyond the northern boundary of the township, for a mile, into T. 64-13. It is found continuing along the southern shores of Basswood lake through ranges 11, 10 and 9. Its southern boundary passes into Canada a little north of Carp lake. It continues northwestward along the boundary at least as far as Iron lake.

The southern mass of gneissic crystallines environs the whole of White Iron lake and the greater part of Garden lake, and appears on Kawishiwi river in T. 63-9. What appears to be the same reappears on Snowbank lake—an unplatted and unvisited township intervening (T. 63-10). The formation completely surrounds Snowbank lake. East of Snowbank, gabbro occupies the probable position of the gneisses, but no characteristic gneiss was found overlaid by gabbro. In the southern part of Kekakabic lake is a chloritic gneiss very similar to the chloritic gneiss which borders the northern crystallines in the IVth Arm of Basswood lake. It might be inferred that this chlorite gneiss is succeeded on the south by micaceous and hornblendic gneiss; but

observation is prevented by the occurrence of gabbro. The inference may be drawn that the gabbro lies on gneiss or granite.

Transition from the Schists to the Gneissic Rocks.—I have mentioned the visible graduation from graywacke to what I have sometimes designated "nascent mica schist" —that is, a graywacke in which fine glistening points appear, which lens-inspection shows to be analogous to fine, pale mica. Similarly a gradual passage exists from the crystalline schists to the geneisses. There is nowhere an abrupt passage from one class of rocks to the other. Proceeding from the schistic side the proximity of the geneisses is announced in three ways: First, by increase in frequency of ramifying veins; second, by occurrence of lumps of gneiss or granite in the midst of the schist; third, by the exact interstratification of schists and gneisses.

In a few cases the intersection of the schists by quartzose or granulitic veins has been noticed so excessive that the resultant rock is a mineral mixture of the two classes of constituents. An observation of very frequent occurrence is the warping of sheets of schist about detached fragments of gneiss or granite found imbedded in the schist. Equally common is the interbedding of schists and gneisses. In such cases an exact comformability between the two exists; and it is beyond question that the schists were subjected simultaneously to the same geological action. As we proceed toward the body of crystallines the frequency of the schist beds diminishes. We have a formation at first three-fourths schist and one-fourth gneiss; then half schist; then one-fourth schist; then one-tenth. After the gneiss is well established a bed of schist occurs once in twenty rods. At first these seem to possess indefinite continuity along the strike. Then they are broken off at both extremities. Then we come to gneiss with only an occasional fragment of schist included. Further on the traces of schist disappear, but scarcely in one instance have I found the bedded character of the gneiss wholly obliterated, when I had the opportunity to examine any considerable breadth of the formation. The details of these transitions have been described and illustrated in the notes already given—especially in relation to Burntside and the western portion of Basswood lake. I have seen no such formation as the granite or syenite described in the books. I have still less found schists or gneisses reposing by abrupt transition on masses of granite or syenite. Least of all have I seen any unconformity between the crystalline schists and the gneisses. Nor finally have I been able to detect the least

unconformity between the gneisses and the earthy schists. I speak only of facts existing within the scope of my present studies. It is not at all improbable that further pursuit of the crystallines would show the gneisses as mere border characteristics, as in the Pyreneese, the Malvern hills and other granitic and syenitic regions.

The Ogishke Conglomerate.—The petrographic characters of this conglomerate are fully set forth in the field notes already given. I do not feel certain that this formation occurs as far west as Vermilion lake; but feel wholly persuaded that it lies in the strike of the western schists, and that it results from a local geological action going on while the schists were accumulating. In the region of which Ogishke-muncie lake is the centre, the conglomerate attains an enormous development. It is everywhere an aggregation of varieties of granitic and quartzose boulders imbedded in a finely granular, mostly greenish, groundmass. With these constituents, we find often, varieties of flint, jasper, granulite, porphyry and "greenstone," so-called. The boulders are in general from one to two inches in diameter; but they sometimes attain a diameter from eight to twelve inches. They are all well rounded. The formation is everywhere solid and indestructible; but in some regions, especially on the southwestern shore of Ogishke-mucie, it has been subjected, apparently, to some altering action which has blended the pebbles with the groundmass, rendering them inconspicuous or undiscoverable within limited areas. The whole rock seems reduced to a diabasic condition. But careful search has in every instance disclosed the essentially conglomeritic character of the rock.

Everywhere the courses of boulders are regularly and precisely interbedded with flinty argillites. These are most abundant toward the northern borders of the formation. The southern borders have scarcely been seen; since the formation seems to be overlaid by greenstones and gabbro. The great bulk of the argillite belt previously mentioned passes north of the conglomerate. Some sericitic beds have been discovered within the limits of the conglomerate area. These facts seem to show that the conglomerate belongs in stratigraphical position within the northern border of the sericitic schists and the southern border of the argillites as they appear further west.

Porphyrel.—I use this term to designate a rock which at first appears like a true porphyry. I have already described its

petrographic characters and its mode of occurrence. It attains a large development on the shores of Dike lake and within the basin of Kekekabic lake. But it is not an eruptive rock. On Dike lake one can occasionally see not only the evidences of bedding and conformability with the adjacent formation, but sometimes, in no mistakable manner, the obscure outlines of pebbles originally existing in the formation. Characteristic as it might seem to be, it is only an ancient fragmental formation, which, by secondary action, has altered the chemical and mineralogical arrangements of the constituents, until its aspect has been completely transformed, and its history almost lost.

Porphyries occur also about Vermilion lake. They have a different aspect from those just mentioned, but I feel persuaded they are similarly the results of secondary action, are in beds conformable with the schists, and might also be regarded as porphyrel.

Dikes and Veins.—Ramifying and tortuous veins intersecting the schists are most abundant in the neighborhood of the gneissic masses. They seldom exceed one or two inches in diameter; but are sometimes seen four inches in diameter, and rarely one or two feet or more. Within a distance of a quarter of a mile of the mass, they may be pronounced quite abundant, but they also occur several miles distant. They sometimes pursue the planes of bedding for limited distances, but generally cross them in every direction. In many cases they are extremely convoluted, and some striking examples have been cited. They are mostly filled with quartz, feldspar or granulite. Rarely is calcite present. Mica and hornblende are seldom seen. In some cases the mode of intersection of different veins reveals two or more epochs of vein-making.

Not unfrequently the larger quartz veins contain crystals of yellow pyrites. The most noted instance has been described from south Eagle Nest lake.

Quite frequently I find epidote the filling of narrow veins; and sometimes these become so frequent as to impart a conspicuous epidotic character to the rock. In a few cases, heulandite, or what appears like it, occurred also in slender veins.

Bodies of isolated rock having a dike-like form are of frequent occurrence. Sometimes these are undoubtedly true dikes, and they seem to consist of diorite, diabase or even of true dolerite. In a single case the dolerite had assumed an amygdaloidal character. This was at Urn lake, Halt 410. In a few cases, the dike is a muscovite granite, as at Halt 91.

Other dikes, so-called, are of a doubtful nature. Assuredly, we find walls of what appears to be foreign rock in the midst of schists — generally sericitic — but they stand conformable with the bedding. They often possess a different color, and a different physical constitution. Their appearance, however, is illusory. If they seem to have properly defined walls, it is only for a short distance. In the near vicinity they blend, on one or both sides, with the country rock. Moreover, when broken, they are found to possess a laminated structure, and this, though sometimes curiously contorted, conforms in general trend, with the strike of the general bedding. They sometimes even reveal traces of a conglomeritic constitution. Examples of such dikes, so-called, are described and figured in the early portion of the preceding notes.

Such are the facts. I do not wish to discuss, in this connection, the real origin of such conditions of the rocks.

It is noteworthy that no alteration in the contiguous formation seems to have been produced by the so-called dikes last mentioned. But in some cases, the dioritic and diabasic dikes have had the customary effects upon the country rock of the vicinity.

Unity of the Entire System.— It is difficult to spend a season on these rocks without acquiring a settled conviction that all the schists, both earthy and crystalline, belong to one structural system. They have one common trend. They possess one common dip. They pass by gradations into each other, both in the direction of the strike and, to a large extent, across it. On petrographic grounds we may discriminate the earthy schists from the crystalline. But even if we did not find the graywacke graduating into mica schist, we should be compelled to say that the two formations were entirely parallel, though belonging to consecutive ages. Nothing but lithological distinction separates them.

Beyond all question, the graywacke belongs in the same system with the earthy schists. Thus then, the whole range of schists is one structural system. I am not maintaining the non-existence of a structural discordance somewhere in the parts of this system. I must state explicitly, however, that I have not discovered it. I have not seen a group of facts suggesting it. I find only a group of facts plainly attesting the unity of the entire system of schists.

The gneisses are not less incontestably bound up with the crystalline schists. Their conformabilities, their intergradations in

constitution and especially in structure, have been pointed out and constitute a body of facts which appear hardly compatible with the doctrine that the gneisses and the schists typify two different geological systems.

Place and Distribution of the Iron Schists.— I inclined at one time to the opinion that the iron ore shists were restricted to particular horizons, and that they extended in ranges somewhat continuous in conformity with the strike of the schists. I have spent considerable time in the attempt to group the various occurrences in one or two ranges. But I have been led to think the doctrine of ranges contains only a partial truth.

I have stated that while the various sorts of schists lie on the whole, in situations parallel with each other, there are also many transitions in the direction of their continuity—the same stratum being at one place argillitic, in another chloritic, and in another sericitic. This sort of relation extends even to the graywacke. Now, whatever theory may prove tenable in reference to the origin of the iron schists, it is a fact of observation that they present in their general features, intimate structural relations with the parallel and embracing schists. While therefore, like the schists, the iron ores exhibit much persistence in the direction of the formational strike, they do not persist without variation or even interruption. Nor do we find all the known deposits actually confined to ranges which can be traced with great persistence. They appear in the midst of the schists sometimes, as a strictly local phenomenon; and no other occurrence is known in the direction of the continuity of the formation.

Nevertheless, it need not be supposed that no geological principle can be employed in the exploration for iron. In the first place, the deposits only exceptionally depart from the belt of sericitic schists—seldom from the central part. In the second place, they may with best prospect be sought along the strike, and especially in the strike of other deposits already known. In the third place, the search seems most hopeful in regions where the sericitic schists have undergone greatest development. These are most widespread in T. 62-14, 13 (south part) and 12 (south part), T. 63-13, 12, 11 and 10, and T. 64-10 and 9.

Gabbro, Gabbroloid, Muscovado and "Greenstone"—These formations are confined to the southeastern portion of the district examined. Gabbro first appears about Illusion and Ima lakes. It walls in Thomas and Fraser lakes, and stretches northeast nearly to Kekekabic. It is generally quite coarse and

quite uniform in texture and composition. It exhibits a tendency to oxidize and disintegrate. In places the amount of iron is very conspicuous. No traces of vertical bedding have been seen in it. It is not conformable with the schists or conglomerates. The only bedding anywhere seen was nearly horizontal, and here it had the irregularity of sheets of successive overflows of molten matter. Only a very partial examination of this formation has been made.

In the vicinity of the gabbro, I often find a somewhat graywackenitic sort of rock which differs from the ordinary graywacke in its waxy color and more granular texture. We have called it muscovado, in consequence of its resemblance to brown sugar: but its true mineral constitution could not be made out. Nor could it be ascertained certainly whether it is a part of the gabbro, or a separate outflow, or a highly metamorphosed schist. Within the district here reported on, the most striking exhibition of it is on the islands of Illusion lake. No bedding could be seen, but the formation, nevertheless, is often equaled by our graywacke in the massiveness of its aspect.

Within the sheet of gabbro I find sometimes a coarsely crystalline rock having much the appearance of gabbro, and seemingly a similar constitution, but it is uniformly finer, and is quite unidentical. I have in some cases denominated it "gabbroloid," but probably it will prove to be essentially gabbro.

The "greenstone" or green rock in the vicinity of Ogishkemuncie lake is not yet understood. On the mountain south of the lake, we find an extensive development of it, and it appears composed entirely of grouped scales of a green chlorite. One would readily decide it to be an eruptive formation. In consonance with such an opinion is the fact that we find on the west side of White Iron lake, a dike filled with the same sort of matter, and indications of similar dikes in other places are noticed.

At the same time I observed on the high hill north of Ogishkemuncie lake conditions of the common formation which closely approach the greenstone of the south side. But these occurrences were indubitably embraced in the conglomerate. Indeed traces of pebbles could still be distinguished, though the whole was almost completely transformed to a homogeneous-looking "greenstone." In fact a similar observation was made on the mountain of the south side. Near the commencement of the occurrence of the greenstone, it was noticed that outlines of pebbles could be faintly traced; and it was at first supposed to be merely

a phase of the conglomerate. Finally, this greenstone is not essentially different from the groundmass of the conglomerate on the southwest shore of Ogishke-muncie, though the latter is incomparably harder.

On the whole, then, I do not feel prepared to state whether the greenstone of the south mountain, or any part of it, belongs to the system of the Ogishke conglomerate, or is wholly possessed of eruptive characteristics.

Thickness of Formations.—The following are distances across the strike of the schists from the gneissic crystallines on the north to the gneissic crystallines on the south:

First section. From the centre of section 22 in Burntside lake S. 26° E. to the centre of section 19, T. 62-11—a distance of 6½ miles. (Section 19 is simply assumed as the probable northern limit of the southern genisses in the direction of the line drawn.)

Second section. From the east end of Burntside lake, N. W. ¼, N. E. ¼, S. 17, T. 63-12, S. 35° E., to vicinity of White Iron lake — a distance of 5.33 miles.

Third section. From the southern extremity of Arm IV, Basswood lake, N. E. cor. S. 28, T. 64-11, S. 29° E., to rapids in Kawishiwi river (Halt 261), S. W. ¼, S. W. ¼, S. 30, T. 63-10 —a distance of 7.18 miles.

Fourth section. From the shore of Basswood lake, S. E. ¼, N. W. ¼, S. 5, T. 64-9, S. 28° E. to west shore of Snowbank lake (Halt 499), in N. W. ¼, S. E. ¼, S. 35, T. 64 9, a distance of six miles.

The proportions of these distances taken up by the crystalline and earthy schists respectively can not be very precisely ascertained, but they may be approximated as follows:

	CRYSTALLINE SCHISTS, NORTH SIDE.	EARTHY SCHISTS.
First section...	.8 mile = 4,224 feet...........	5.7 miles = 29,596 feet......
Second section.	.5 mile = 2,640 feet...........	4.83 miles = 25,502 feet......
Third section...	.5 mile = 2,640 feet...........	6.68 miles = 35,270 feet......
Fourth section.	.5 mile = 2,640 feet...........	5.5 miles = 29,040 feet......
Average ...	3,036 feet	29,852 feet

The graywackenitic belt, which is included above in the earthy schists, may be said to have a variable width of about half a mile. In the vicinity of Garden and Farm lakes, the graywacke spreads over at least two miles. But where the graywacke is wider, the sericitic schists are narrower.

If these schists are to be regarded as folded together, the true thickness of the system would be half of the numbers in the above table.

East of range 9 I have not the data for giving the thickness of the schists between the gneisses. Nor do we find the schists extending southward to gneissic crystallines. As already stated, they are terminated, as a surface formation, by the gabbro; and the study of the region has not yet revealed the nature of the rocks underlying the gabbro. The following, however, are some facts respecting the length of the section across the schists in the vicinity of Ogishke-muncie lake.

If from the gabbro at Halt 834, in the southern part of Gabimichigama lake, we draw a line through Campers' island in Ogishke-muncie lake, N. 15° W, it gives us a section across the strike. Then, from the northern border of the gabbro, the distance across the graywacke is approximately 1¼ miles. The next three miles are across the Ogishke Conglomerate, and that is regarded as extending to the mountain visited south of Knife lake. In this neighborhood, the conglomeritic character of the formation has nearly disappeared, and argillite prevails. Beyond this, argillite extends at least four miles. This whole distance is 8¼ miles. But the direction is not at right angles with the strike. Nor is the strike at all uniform throughout that distance. At points within the region it is N. 82° E. (Halt 824). South of Ogishke-muncie lake generally, we find it from 53° to 78° west of north—trusting to the indications of the needle corrected for regional variation. On the the north side of the lake it ranges from N. 22° E. to N. 47° E. It would be idle, therefore, to attempt to calculate from the length of this section and the direction of the strike, what would be the distance in a perpendicular line across the strike. One might estimate in a rough way, that the schists and conglomerates are here six miles thick, of which the Ogishke Conglomerate makes at least 2½ miles.

We have some means for arriving at an estimate of the vast thickness of the gneissic and granitic formations. The second section, produced northwesterly from Halt 643, will nearly strike Halt 723, at the further extremity of Crooked lake, the most remote point from the central axis of the schists which was reached by the present exploration. This is a distance of 17 miles in a straight line. Over the whole distance, traces of the bedding common to the entire system can be seen; and there is evidence that the whole distance should be reckoned as repre-

senting a portion of the proper thickness of that mass of rocky matter which became the gneiss and granite of the region. This gives to the gneissic crystallines an observed thickness of 89,760 feet.

Morphological Phenomena.—I wish to group here first, some of the facts observed in connection with graduations between one rock or mineral and another; and secondly, a few isolated phenomena connected with the modes of occurrence of some geological conditions. These phenomena I speak of simply as facts without any reference to their origin.

As to gradations from rock to rock, I wish chiefly to recapitulate what has been said.

1. From sericitic schist to argillite. All intervening conditions as to color, seritization, solidification and induration may be noted. This transition is of course most frequent between buff and dark argillites.

2. Between sericitic schist—especially the argillitic varieties—and chloritic schist. All intervening conditions occur. The progress ends in a schist which is eminently and characteristically a chlorite schist. But beyond this is a chlorite rock so profoundly altered that even the schistic structure is disguised. The rock is a ragged mass of irregular chunks compacted together. Seen especially at the falls of Fall river. It is less advanced on the shore and islands west of the falls in Fall lake. Compare Halt 529.

3. Between graywacke and sericitic schist. The passage is often observed along the line of strike, but more frequently across it. Often a stratum which is obstinate graywacke at one point is a slaty rock within a few feet.

4. Between graywacke and chloritic graywacke. As in the chloritic modifications of sericitic schist, so those of graywacke proceed until the rock is almost a compact chlorite, but possessing all the hardness of the primitive graywacke.

5. Between graywacke and hornfels. I have not applied this name to the highly indurated condition of graywacke of which I have already spoken. Hornfels is described as a contact result, especially contact of fine graywacke with granite, as in the Harz, but many examples of highly indurated graywacke deserved to be recognized as hornfels, although generally quite remote from granite. The transitions are very often noticed.

6. Between graywacke and "nascent mica schist." A transition observed in numberless instances. Within a few rods, in

most cases, a "nascent" micaschist discloses itself with fully developed mica. See Halts 522, 527, 528. The passage directly to mica schist is seen at Halts 72, 73 and 74.

7. Between biotite schist and hornblende schist. The passage is essentially one from biotite to hornblende, generally diallage. At first some fine hornblende individuals appear among the fine biotite scales. Occasionally an individual is seen which is biotite on one side and hornblende on the other. At Halt 233 the transition follows the strike and also crosses it.

8. Between muscovite schist and sericitic schist. The muscovite scales grow finer, thinner and whiter at each step. An example at Halt 69. See also Halts 329, 334, 554.

9. Between conglomerate and argillite. An entirely usual passage, resulting simply from the diminution and cessation of pebbles. At Halt 114 the weathering of schists develops a puddingstone structure.

10. Between conglomerate and sericitic schist. See the description at Halt 315. Compare also the conglomerate of Stuntz island in Vermilion lake. See also Halt 467.

11. Between conglomerate and diabasic rock. Both by augmentation of groundmass and by alteration, both of pebbles and groundmass. At the end of the series the pebbles are scarcely discernible, and the whole formation is strongly diabasic. Seen in Ogishke-muncie lake on the western and southwestern shores.

12. Between conglomerate and a "greenstone." The outlines of the pebbles can occasionally be traced. On the mountain south of Ogishke-muncie, and also the one on the north.

13. Between conglomerate and porphyrel. Porphyry in which outlines of pebbles can be traced, and also the rudiments of bedding. Occurs at several points in Zeta and Dike lakes, and in the central part of Kekekabic.

14. Between diorite and sericitic schist. At Halt 116, a fine compact diorite (supposed) weathers to the aspect of a sericitic schist.

Among other phenomena may be mentioned the following:

1. Felsitic veins split by quartzose veins. Halt 91.

2. Structure lines in dikes and veins conformable with bedding of the formation. Seen in a granite dike running with the stratification at Halt 91. Seen in sericitic vein-forms at Halt 56. Compare also Halt 3 and dike-forms at Halt 334.

3. Structure lines in veins not conformable with the bedding of

the formation. At Halt 54 are sericitic veins which possess intersecting lines of structure.

4. Dikes and veins with schistose or slaty structure. At Halt 104, veins of micaceous and hornblendic character occur. The matter appears derived from schists. At Halt 111 is a dike-like form consisting of hydromica schist. Develops conspicuous fibres on weathering. A similar phenomenon at Halt 113, but conformable with the bedding of the formation. A similar one at Halt 565.

5. Relation of crystal axes to planes of bedding. Axes seen coincident in numberless cases. Axes seen transverse in many cases, as at Halt 122, where hornblende crystals cross sericitic schist.

6. Relation of crystal axes to walls of veins. Both attitudes are illustrated at Halt 233.

7. Bedding of unsedimentary rocks. Granite extensively, on Basswood lake. Gabbro on large island in Gabimichigama lake. See Halt 840.

8. Quartz grains overgrown by feldspar. Halt 411.

Drift.—A thin sheet of drift is present in most parts of the region, but it is difficult to discriminate between superficial deposits of such character and those which result from simple surface destruction of the rocks. While we find a large abundance of transported and characteristically rounded rock fragments along the lake shores and through the interior, it is a striking fact that along many shores we find almost exclusively angular fragments, or those simply bruised by modern lake ice. A region comparatively boulderless includes Snowbank Lake, and, as I am informed, a district southward from there.

Seldom are any very large boulders found. Some boulder-like masses strewn along the Rapids No. 6, in the stream on the boundary (Halt 688), far exceed the average size. In a few cases very large rock fragments were noted, which seemed to be mere fragments of a contiguous formation not far removed from place, rather than true erratics. One of these was found on Stuntz' island in Vermilion lake—a poroditic mass. Another was on an island in Burntside lake, and measured some 18 feet in diameter.

Nothing like extensive morainic deposits was anywhere found.

The direction of the glacial striæ in all parts of the region is about S. 21° W.

That the entire region has undergone a vast amount of denudation is a fact everywhere apparent.

That glacial action has been generally operative and efficient is shown by the smoothings and groovings so generally seen on the exposed rock-surfaces. But too much of the vast denudation must not be attributed to glacial action. The general surface for millions of years was exposed to the oxidating and disintregating influences of the atmosphere, before the epoch of continental glaciation, and a vast volume of comparatively incoherent material was already prepared to be swept away. Still we are reminded again, that no very great volume of drift products has been deposited within the region, and the conclusion must be either that a large portion was transported beyond the limits of the region, or the pre-glacial decay was not as great as might be inferred from the truncation of the salient masses of rock.

Topographic Features.— It is worthy of note that the longer axes of the numerous lakes do not conform with the strike of the rocks nor the direction of the glacial striation. In the western part of the region, within the schistic limits, the general trend of the lake axes is about N. 65° E., and this is not much less eastward than the mean strike of the schists. In the eastern part of the schistic district, however, the lake axes are more eastward, while the schistic lines are more northward. In other words, the trends of the lake axes in the western region conform more with the geological structure and less with the direction of the glacial action. In the eastern part of the region they conform still less with the glacial action, and lie still more across the lines of rock structure.

This, at least, is the conclusion from the indications of the magnetic needle. But I feel much suspicion of these indications in the eastern part of the region, and should prefer that the bearings should be re-examined with the aid of the solar compass. I am not fully prepared to believe that the axes of Kekekabic and Ogishke-muncie, for instance, lie across the rock strike at so great an angle, nor that the strike actually makes so small an angle with the meridian as is shown in my notes.

§ 31. PROVISIONAL INTERPRETATION.

Only details of fact have so far been presented. These were intended to enable each reader to draw his own conclusions as far as can be done from a survey of a part of the field involved in the interpretation. For my part, I am not prepared to enunciate many conclusions except in a tentative way. But some partial conclusions are deemed obvious, and will not be negatived by further studies, and some suggestions may be allowable even while subject to revision.

The Structure of the Region.—Evidently, this extensive region of vertical schists has been subjected to powerful disturbances to place the body of rocky sheets on edge. It was a widely felt disturbance, for the nearly uniform strike and dip have been traced for a hundred miles, and few merely local irregularities have been noticed. Thousands of square miles of surface must have been moved consentaneously. Does the belt of vertical schists present a single series from side to side, or a single close fold with the duplication of a series, such that from a middle line the stratification is the same on both sides, but in inverse order? Or are several folds present, causing more than one duplication of the succession of strata?

If no fold exists, the thickness of the system is the length of the line measured across the strike. If one fold exists, the thickness of the system is half the length of that line. If n folds exist, then the thickness of the strata would be shown by the distance across the belt of schists divided by $2n$. In other words if T is the thickness of the formation, d, the distance measured across the strike, and n the number of folds, then in the equation, $T=\frac{d}{2n}$, if we substitute 1, 2 and $\frac{1}{2}$ successively for n, we get $T=\frac{1}{2}d$, $T=\frac{1}{4}d$ and $T=d$.

Now, I think no geologist could cross the belt of schists many times without feeling convinced that the existence of several folds is an impossibility. I feel myself confident that no such recurrences of similar strata are observed as the existence of more than one fold would necessitate. On this question it seems to me that nothing more is to be said. I think a multiplicity of folds could not conceal their existence during a three months' investigation. This is one of the points which I shall set down as settled by the study of only a portion of the entire region.

Do we recognize then, the existence of a single fold? I

believe we do, and the following facts appear to demonstrate its existence:

1. In the greater part of the region examined there exists on the north an extensive development of gneissic crystallines, which grow less schistose as we proceed northward, and may reasonably be expected to pass into a strictly non-schistose state. This mass, whether gneissic or granitic, I will call the northern crystallines. On the south we find a similar mass which I will call the southern crystallines. Here, then, are two extended regions of upheaval. They stretch along either side of the schistic belt. They are adequate to have lifted and brought to a vertical attitude on each side the long body of schists which have been thus moved. There is no other crystalline mass in any such relation to the schists as to give plausibility to the suggestion that the schists had been disturbed by it. The very situation then is one which gives antecedent probability of the existence of a single fold rather than more.

2. Let us examine the succession of strata standing between the northern and southern crystallines. If we take the interval between the gneiss of Burntside lake and the syenite gneiss of White Iron lake, we find on the north side that the beds standing in contact with the crystallines are mica schist. On the south side the beds standing in contact or continuity with the syenite are also mica schist, as seen at Halts 223, 233, 230 and many other localities.

Then next the mica schists of the north we find some hydromicaceous and graywackenitic schists; on the south, next the mica schists, is a broad belt of graywackenitic schists covering most of Garden lake, and often approaching the hornfels condition. Further east and west similar schists follow the mica schists.

Between the belts of graywacke lies the great body of earthy schists. Still, as before said, the chloritic and argillitic tend rather to the outer border of the belt, while along the middle the schists are predominantly sericitic. Here, also, are the hæmatite deposits. If the ores do not occupy the very highest stratigraphical position there would be two iron belts outcropping. I am not yet satisfied that this state of things exists. I can only say at present that the ores occupy the middle zone coincidently with the sericitic schists.

If the strata are recurrent in inverse order on opposite sides of the central axis, there must exist under ground a continuity between the mica schist of the north and the mica schist of the

south; between graywacke of the north and south, the earthy schists are simply folded together, and the crystallines of the north pass down and under all and reappear in the crystallines of the south. The situation would then be represented by the following diagram:

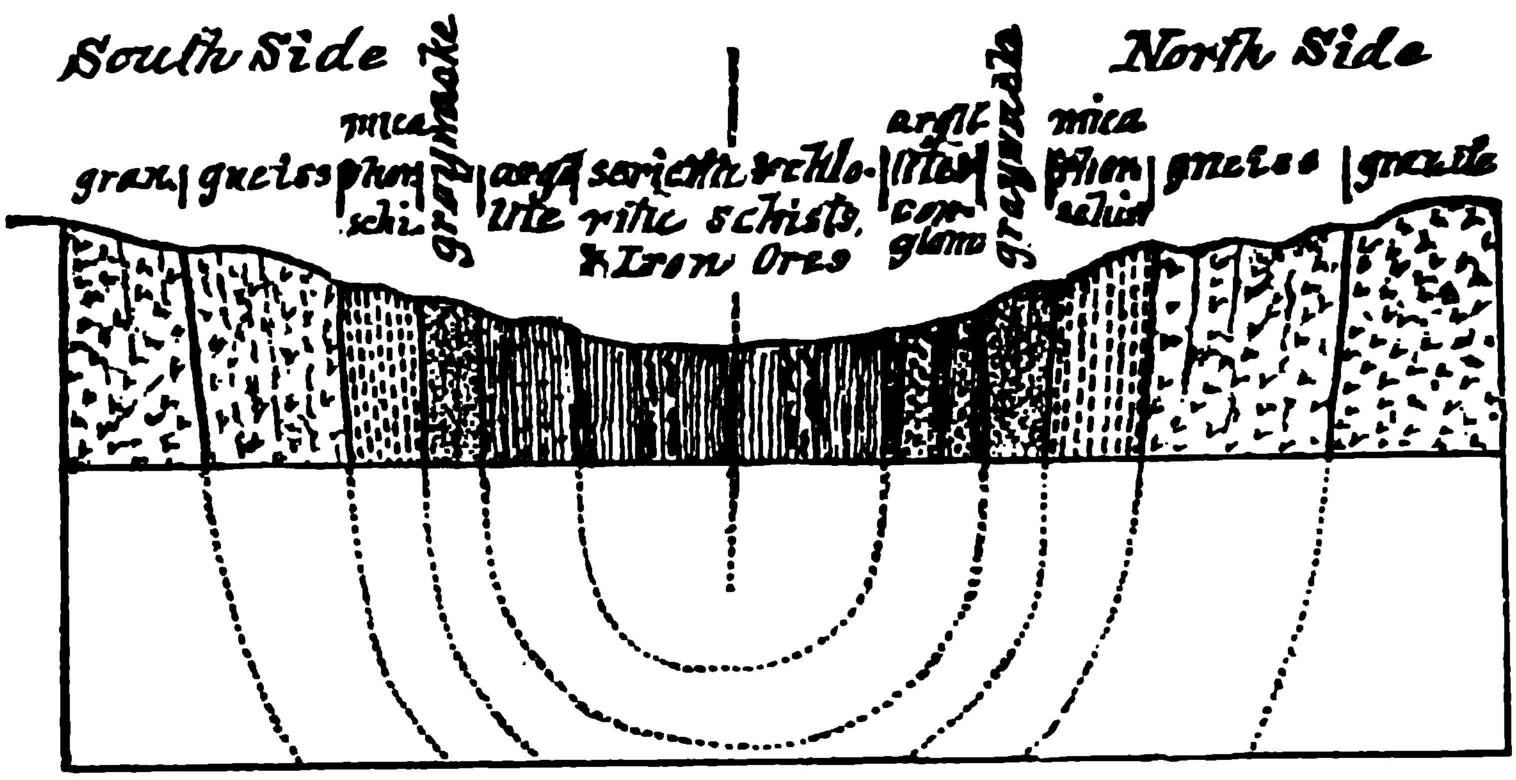

Fig. 57 Theoretical folding of the Vermilion series of schists.

a, *a*, Earthy schists. *b*, *b*, Graywacke. *c*, *c*, Mica schist. C. C. Crystallines.

From this showing, the true thickness of the bedded rocks of the region would be as follows:

First section,	Crystalline	schists,	2,112	feet.	Earthy	schists,	14,798.	Total, 16,910
Second section,	"	"	1,320	"	"	"	12,751	" 14,071
Third section,	"	"	1,320	"	"	"	17,635	" 18,955
Fourth section,	"	"	1,320	"	"	"	14,520	" 15,840
Average,	"	"	1,518	"	"	"	14,920	" 16,444

To this aggregate of schists may be added the observed breadth of gneiss on the north side, making a total thicknes of 106,204 feet.

The schists therefore rest in a basin formed in the general mass of crystallines. They occupy a geological valley. We take no note of the form into which the exposed surface has been carved.

It will be noticed from the details of facts given, that the original bedded accumulation does not end downward with the mica schist. A bedded structure strictly conformable and strictly in continuity with that of the schists continues into the deeper crystallines, rendering them all gneissic to the further limit of the observations. We must endeavor to think all these

bedded rocks again in a horizontal position. We then see the earthy schists at the top, followed down by the graywacke and the mica schists, and these still underlaid by intercalations of schists and gneisses, and at the deepest horizon reached, passing apparently into a true granitic rock mass.

This is the character which the succession would have if all were restored to the condition of horizontality. But it is not necessary to conceive that horizontality was retained until each of the series of rocks had attained the petrographic state in which we now observe it.

2. *The Geological History of the Region.*—I am led to think that we may trace in the petrographic and structural phenomena of the region the records of two periods of geological activity—a period of sedimentation and a period of alteration. I conceive the whole mass of rocks brought under consideration to have existed originally as sediments. I express the opinion as an inference from the facts observed within the region, not in conformity with any general theory of primitive terrestrial conditions. Nor do I consider the geognostic causes which so changed the conditions as to introduce heat and metamorphism where aqueous conditions had long prevailed. The rocks—all the rocks—present to me the aspect of sediments more or less altered. Respecting the succession of beds as far down as the graywacke, no difference of opinion will probably be entertained. No one could reasonably exclude the graywacke from the sedimentary series—massive and semi-crystalline as it sometimes appears. It stands in too close relations with the argillites, and affords in itself too many features of stratification to permit the question to remain.

It is but a step further to discover the evidence of the sedimentary origin of the crystalline schists. Their stratification is no less positive than that of the graywacke and the earthy schists. It is scarcely more obscure than that of the graywacke. To assign a sedimentary cause for the structure of the graywacke and seek for another—an antipodal cause, for the similar and parallel structure of the mica schists is to reject an explanation which is probable and adequate, and invent one which is purely hypothetical, and implies a system of coincidences with the structure of the earthy schists which it seems to me is infinitely improbable. I can understand that igneous fluidity may be capable of disposing matter in parallel sheets, but even if it could produce sheets of as great regularity in position and thickness

as the processes of aqueous sedimentation, I do not feel driven to appeal to such a cause of bedding in the crystalline schists and recognize a sedimentary cause in the contiguous and conformable graywacke and earthy schists.

Similar reasoning leads me to trace sedimentary causes through the entire breadth of the gneisses. If originally sedimentary, these have indeed been so altered as to obscure progressively the traces of their ancient condition. If, at the extreme of the series, there be rocks without a trace of sedimenary action remaining, I am willing to believe it has been simply obliterated. The continuity of the succession is too manifest to permit me to think the gneisses experienced an origin totally different in its nature from that of the granites into which they graduate and to which they are inseparably welded.

In what form the original sediments of the gneisses at first existed, I will presently inquire more particularly. The graywackes which still retain something of the sedimentary condition, exhibit evidences of accumulation under circumstances similar to those of later formations. The Ogishke Conglomerate and the argillites present no features of sedimentation in any respect exceptional. It is a fact of much interest that the conglomerate has preserved examples of so many species of granitic and silicious rocks. We might pause a moment to inquire into the conditions of this pebble accumulation. Evidently there were already in existence consolidated masses which had acquired the condition of granite. Somewhere stretched established shores whose slow degradation afforded the materials of this conglomerate. Violence there must have been to disrupt the rocky masses. Violence there must have been to impart such movement to the waters as would cause the attrition and wastage denoted by the thoroughly rounded forms of the pebbles and boulders.

But that ancient granite was not the granite immediately underlying, and which we have studied in the progress of this work. The underlying granite was not yet uplifted. The gathering beds of pebbles were still lying horizontal, and no great disturbance had been felt by any part of the system of formations which we have investigated and have felt disposed to pronounce a unit in its history. This inference is confirmed by the character of the conglomerate constituents. We find there two or three varieties of granite differing from any discovered in the formations of this system. We find flints and jaspers which, as

far as we have explored, could not be afforded by any part of this system. We find nothing which indisputably could have been derived from any member of the system — the Vermilion system, ranging from the granites to the earthy schists. Those older rocks whose destruction afforded material for the building up of the Vermilion system belonged to an earlier age and were parts of an older system. Whether either was what geologists have styled the Huronian system or the Laurentian system, or whether they present us the two systems, or some other systems, the observations of this exploration do not enable us to decide. It yet remains to see one or both of these systems in continuity with, or in some intelligible relation to, some identifiable body of rocks. Of this, however, I feel authorized to testify— the range of rocks lying within the field of my explorations in Minnesota represents but *one system*. I can not, so far, discern any grounds for assigning different parts to different great systems.

There was next a period of disturbance and alteration. The principal features of the alteration I suppose to be as follows: 1. The crystallization of the materials of the gneisses and crystalline schists, and the obscuration of bedding planes. 2. The formation of dikes and veins. 3. The porphyrization of portions of the sediments. 4. The softening and incipient transformation of the mineral and chemical constituents of the conglomerates and some of the earthy schists. 5. The partial sericitization of portions of the argillites. 6. The commencement of the elimination of ferrous oxide from certain minerals in certain formations, and the accumulation of it in distinct regions and specific horizons. 7. The simultaneous disengagement of free silica and its lodgment in the spaces vacated by the progressing transformations, especially within the theatre of ferrous oxide formation.

These changes — physical and chemical — are of such a nature as to evince the action of heat in conjunction with water, and may be referred to as thermal alterations. I recognize, also, another category of changes which seem attributable to the agency of water and oxygen without extraordinary heat, and these I will refer to as athermal. I understand that both thermal and athermal changes have been effected largely through the instrumentality of chemical action. Perhaps it would be more exact to say that chemical action has been the general and the real cause, while the presence of heat, water or air has af-

forded the conditions under which the chemical action has proceeded. Among the athermal results of alteration I would place: 1. The oxidation of portions of the argillites. 2. The extensive chloritization of the earthy schists. 3. The partial decrystallization of some of the injected products. 4. The foliation or fibrous texture of some of the abnormal dikes. 5. The silicification of portions of formations. 6. The probable formation of some of the quartzose veins. 7. The continuance of the accumulation of ferrous and ferric oxides and the consequent augmentation of the iron ore deposits.

As to the method and circumstances of that altering action which inaugurated a new epoch in the history of the sediments of the Vermilion system, we may pause to contemplate a few deductive inferences. We can not, with confidence, determine the cause of the change in the nature of the geologic actions exerted. We perceive, however, that the region had been a long time sea-bottom, and for ages sediments coarse and fine had been accumulating over it. I have shown that the sediments which underwent consolidation into schists have given us a thickness of 16,000 feet of rocks. I have shown that the schists and gneisses, all conformably bedded, constitute a thickness of 106,000 feet. The accumulation of this covering over the bed of the ocean must have exerted an important influence over the relations of the interior and exterior of the earth. If the increase of temperature downward was at that time at the rate of one-fiftieth of a degree Fahrenheit per foot, a temperature of over 2,000° must have existed at the bottom of this bed of sediments, and 1,000° at mid-depth. It is not necessary to assume that just these temperatures existed, to feel convinced that some high temperature had come into existence which must lead to important changes in the beds of sediments.

This thermal condition was not acquired suddenly. The temperatures had been rising progressively during all the ages in which the sedimentation had been in progress. Each horizon of sediments had experienced an ever-increasing intensity of heat. The energy of the action had been progressively augmented. It had been quiet; it grew to become violent.

The heat was not sufficient at the lowest horizon here considered to fuse the mineral substances. But we understand that at a temparature less than 1,000° many minerals are softened or even resolved in the presence of water and alkaline agents. This was the situation in the depths of the sedimentary sheets of

the system. The actions are too familiar to justify a recital of them. For unknown ages, while resting beneath the ocean's waters, they were soaked and heated and boiled incessantly. The busy forces of heat and chemism undid the combinations which had previously existed, and, under new conditions, succeeded in rebuilding the elements in new molecular and mineral aggregates. What was the precise nature of these silent processes it is not my purpose or province to describe. Much has been done by recent investigators to throw light on their nature. Among American laborers in the field, I am glad to acknowledge my indebtedness to Wadsworth, Irving, Van Hise, Becker, Pumpelly, and others.

It was during this epoch, as I conceive, that the most important of those metamorphic actions took place which made these rocks what they are — the deeper-seated being more changed than the newer. At times, the growing energy of the action disturbed wide regions. The movements of the beds — long before consolidated — rent and shattered them in various degrees. As soon as a rent was opened it was filled by some contiguous matter in a molten or in a plastic state. The profoundest fractures pierced most deeply into the crust of the earth, and opened into matter resting in a state of complete fluidity. Or else, opening into a region of matter kept rigid by enormous pressure, brought relief to the pressure and consequent fluidity to the matter. Other fractures reached only to the zones softened by aqueo-igneous action, and received only injections of softened matter which cooled at some later period, retaining upon it the ambiguous traces of both fire and water. Sometimes the fissures in a rock mass were filled with a more softened portion of the rock itself squeezed in and retaining the peculiar dike-like form, while composed of matter undistinguishable from the country rock. Not unfrequently, especially in the shallower zones, the rents received simple aqueous solutions, especially of silica and alkalies, and the fissures became filled with quartz or quartz and feldspar.

In the earlier part of this tumultuous history, there was a period during which gneiss-making and schist-making conditions began to alternate. Then the schist-making conditions began to recur more frequently. Then they persisted for awhile. This was the the most uneasy epoch passed before the final uplift. Not unfrequently alien fragments were deposited on the ocean bed, and the gathering sediments settled around

them. These fragments were thrust up from beneath, or brought by violent movements from some different situation. After the zone of crystalline schists had been buried, the history was marked by comparative quiet, save along the ancient shore whose slow destruction was yielding materials for the Ogishke Conglomerate. Again, however, in the epoch of sericitic schists, there appear to have been renewed disruptions. Fragments, not of gneissic but of quartzose strata, were scattered over portions of the ocean's floor, and around these the sheets of sediments were wrapped, as in other seas and earlier times. Often a field of sediments hardened already, perhaps by silicification, was shattered into numerous fragments, and again the work of silicification recemented them, before they were dispersed.

I desire only to indicate the general tenor of the actions which appear to have taken place even before the final upheavals which brought the beds to a vertical attitude. It would be difficult to ascertain what juncture in the progress of these activities determined a sudden increase in the degree of mechanical violence. It appears probable, however, that the movement of upheaval was rapid. While the strains were accumulating, the body of the sediments remained comparatively unmoved. When the accumulated strains overbalanced the power of resistance, the crisis was sudden and brief. Somewhere on the north, the deep zones of softened sheets were urged upward with such energy as to break through the overlying strata, and to reach, probably, the level of the ocean. Somewhere on the south, the deep zones of softened sheets were simultaneously raised through the rent schists. The mechanical action exerted on the broken schists and gneisses raised their opposite edges along the two entire slopes of the granitic emergences. Pressed from the north and the south simultaneously, by the tendency of the two regions of emergence to unite, the schists suffered a complete folding together. I imagine that their own weight, when raised on edge and narrowed in lateral extent, caused such a subsidence into the deeper regions of the terrestrial crust as to bring their downward continuation within the zone of destructive heat. These schists then have become the mere stubs of their former extension.

Such movements could not take place without the occurrence of many fractures and the injection of many new dikes and veins. I conceive, therefore, that some of the dikes stand in the attitude in which they were originally formed. These are dikes

of the second era. The primitive dikes, however, have been brought to rest on their edges. The direction which represents their ancient downward continuity is that toward the granites.

I am led to think the upheaval signalizes the close of the violent actions which have left their marks upon the system of rocks, while for many ages the scarred and transformed strata have rested in the attitudes in which we have made their acquaintance, those further and less fundamental changes have been in progress, and are still continuing, which I designated as athermal.

With this general outline of the probable history of the region which has been the theatre of a season's study, I leave the more detailed investigations in the nature of the rocks and their molecular histories to future opportunities and to other hands.

3. *Were the Gneisses originally Sedimentary?*—The importance of the subject requires a return to the special question of the gneisses. I am quite aware that an impression prevails that a substantial unconformity exists, or ought to exist, between the gneisses and the crystalline schists. I have been much impressed by the treatment which has been given the question by Mr. Andrew C. Lawson in his very able and well-considered report of the geology of the region of the Lake of the Woods. There is much resemblance between the "Keewatin series" and a part of the Vermilion system. The former, however, is completely isolated from other schists. It lies in a circumscribed basin instead of a long trough, and has been pressed by granite upheavals on all sides. It has, therefore, undergone somewhat different disturbances. But the relations of the crystalline schists and the contiguous gneisses appear to be precisely like their relations in the Vermilion system. It has been the opinion of the earlier geologists, Bigsby, Bell, G. M. Dawson, Selwyn, that the schists and gneisses are conformable. Mr. Lawson, however, argues that no real conformity exists. He recognizes the complete conformity between the bedding planes of the schists and the planes of foliation of the gneisses. But the latter, he maintains, have no necessary or probable dependence on the possible sedimentary planes of a deposit from which the gneiss has been produced. I understand Prof. Irving to place great reliance on the same principle. Mr. Lawson regards the gneisses as having essentially an igneous history. With him, the sheets interbedded with the hornblende schists are dikes, and belong to a later age and a different mode of geological action.

The question is one of such fundamental importance that I quote the passages in which the essence of Mr. Lawson's argument is embodied. He says: "It is highly improbable that the foliation of the gneiss has anything to do with an original sedimentation. * * * * Gneissic foliation is seen to have been developed in a rock which was once in so liquid or viscid a condition as to permit the passage through it of angular blocks of schist to considerable distance from the source from which they were detached. A rock to have been in a state so yielding must necessarily have had all traces of an original sedimentation, if any such existed, obliterated. Furthermore, the existence of a well-marked foliated structure in dikes which have been injected within the schist, both parallel and transverse to its lamination, and which are sometimes traceable in unbroken continuity with the main area of the gneiss, proves conclusively that such foliation was induced in the rock subsequently to its having been soft enough to have undergone injection, and, therefore, to have had any traces of sedimentation destroyed. * * * As a matter of opinion, I incline to the belief that the granitoid gneisses of the Laurentian were never aqueous sediments." Speaking of the interbedded schists and gneisses, of which in one case he enumerates sixteen recurrences of gneiss, he says: "These bands of gneiss, alternating with the schist, are for the most part regular and bed-like in their character, but their true nature as injected sheets or dikes is sufficiently revealed." Speaking of the lack of evidence of sedimentary stratification in the gneiss, he says: "There are some considerations which point to a very distinct historical and natural break between the two series. The most evident of these is the sharp contrast in their lithological characters."

These considerations possess weight, and challenge careful examination. I proceed to summarize briefly the facts which have led me to believe the foliation of the gneisses sustains a relation of dependence on an antecedent sedimentary structure. In making a statement of these, it will appear how I would propose to overcome Mr. Lawson's difficulties.

1. The gneissic foliation follows very exactly the planes of schistic sedimentation. This has been sufficiently shown in the details of the field notes. The fact is admitted by Mr. Lawson, and recognized by many other observers.

2. No reason can be given for supposing subsequent foliation would so closely follow the schistic sedimentation unless a sedi-

mentation had originally existed in the gneisses strictly conformable with that in the schists. This truth the schists themselves illustrate. The schists as truly as the gneisses present us the original sedimentary material transformed by metamorphic action into crystalline forms. As truly as the gneiss, they exhibit a foliated structure. The foliated structure, as everyone knows, follows closely the planes of the original bedding. It is fair to presume that the similar and parallel planes of foliation in the contiguous rocks follow also real sedimentary planes.

The foliated condition, or what is fundamentally the same, often exists in schists less metamorphic. Lawson, speaking of the "clastic agglomerates" refers to "the planes of schistosity which are in the great majority of cases observably identical with those of the bedding."

3. The gneisses and crystalline schists are cognate in composition as well as in structure. Quartz, feldspar and mica or hornblende are the fundamental constituents in both, but with a less conspicuous presence of feldspar in the schists. Lawson says: "It is not uncommon to find in these mica schists a small proportion of feldspar." Bayley, cited by Lawson, states: "Throughout this microcrystalline groundmass are scattered irregular pieces of kaolinized feldspar, porphyritic crystals of the same mineral, with beautiful zonal structure, fresh plagioclase with twinning lamellæ." Some of the hornblende schists are similarly feldspathic. It would hardly seem that the difference in composition between the gneisses and schists is such as to allow the inference that the metamorphic planes conformed to bedding in the schists, and compel us to seek for the explanation of the metamorphic planes of the gneisses by appeal to "a totally different mode of action."

4. If the gneisses possessed a very *different* mineralogical constitution, that would not forbid the reference of their parallel planes of metamorphism to similar causes. Among fossiliferous rocks it is a fundamental principle that contrast of mineral characters in successive strata is no conclusive evidence of difference of epoch.

5. It seems eminently improbable that the gneissic beds intercalated in the schists should be of the nature of dikes. One feels prompted to follow the suggestion with an exclamation point. These gneissic sheets are too numerous, too exact in their parallelism with the schistic beds, and often supported by schistic walls too slender to give countenance to the conception.

Mr. Lawson enumerates in one instance 17 beds of gneiss which alternate with 16 beds of hornblende schist, and one of the beds of gneiss 100 feet thick stands between two beds of schist five and twelve feet thick. It is only conceivable that this alteration was effected before the upheaval; and if so, the schists and gneisses belong to the same epoch — even if the gneissic sheets were overflows of molten matter.

6. Fragments of gneiss very frequently occur in the schists. Hence the gneiss is older than the schists, and could not have been injected into them.

7. The gneissic fragments found in the overlying schist have their planes of foliation in all positions, regardless of the bedding of the schist. If the schistic bedding controlled the foliation of the gneiss immediately below, it would be able to control that of gneiss bodily inclosed.

8. The foliation of the gneisses diminishes as distance from the schists increases — showing that it is inversely as the amount of alteration. As signs of sedimentation diminish, foliation diminishes. The foliation shows some dependence on sedimentation. Its presence is evidence of predisposing sedimentary structure.

9. The adjustment of planes of foliation to foreign fragments, as seen in the wrapping of the folia about masses of schists, reveals the tendency of the foliation to assume relations to external material conditions. It is a coincidence in detail with probable sedimentary arrangements which in the general foliation, we see exemplified, as I think, upon the large scale. The foliation-planes follow the sedimentation-planes in the one case as in the other. Unless planes of deposition act as predisposing conditions on the position and conformation of planes of foliation we should expect the latter to occupy positions out of any relation to objects which might have determined the forms of sedimentation-planes. As a fact, their relation is so close that they follow exactly the lines assumed by the sedimentation features. All these things reveal a connection of dependence between foliation-planes and pre-existing sedimentation-planes.

10. Injected veins do not prove the igneous origin of the whole gneissic mass — nor a completely igneous condition of any part of it — but only a softened state, which, as we know, might be produced at a temperature far below that of igneous fluidity.

11. The foliation often seen in veins — especially those veins before spoken of, in which the vein-matter is closely cognate

with the country rock — may, in many cases, sustain a relation to the earlier sedimentation-planes of the closely contiguous rock with which the vein is in continuity. If so, the planes of foliation might be parallel with the contiguous walls, or at any angle with them. As a fact we find them in some cases parallel and in others inclined to the walls. But if vein-foliation were quite independent of a previous bedded condition of the matter — as undoubtedly is the case in foliated veins of igneous origin — the diverse position of those planes in relation to the vein-walls shows that a contiguous rock-surface is incapable of controlling the position of the foliation-planes; and hence the foliation-planes of the gneiss must have been determined in position by something more than the surfaces to which they have become parallel. We are left again to the most probable supposition, that the conformity with bedding-planes which may have existed is due to some condition in that to which the conformity approaches closest — that is to sedimentation.

12. It is admited that the gneiss, during the period of its metamorphosis, was probably in a pasty condition, though we have no proof that blocks of schist were very far transported in it. Some limited, deeper-seated portions may have approached a state of igneous fluidity. As a general principle, however, the more highly heated portions of matter did not present the conditions of gneiss-making. They afforded diorites and some granites, more especially diabases, norites, gabbros and dolerites. The zone of the gneisses and most of the dolerites lay between the rocks retaining a characteristic sedimentary condition and masses of matter returned from a sedimentary to a molten state, or else — especially in the deeper region — retaining the molten state from a primordial epoch. We are at liberty to assume for portions of the gneisses, any degree of fluidity which observed phenomena seem to indicate; and yet, for the great body of the gneisses, recognize such a history as is indicated most plainly by the general tenor of all the most accessible facts.

13. Some of the difficulties experienced by geologists, especially German geologists and their followers, in admitting a former sedimentary condition of most gneisses and granites arises, probably, from too narrow a conception of geologic history. The period of our gneisses and granites was probably very long subsequent to the intervention of the ocean in producing crustal modifications. Not only were our gneisses and granites once real sediments, as I venture to think, but beneath them were earlier

sediments unknown to us, which became progressively softened and fused, with the progress of later sedimentation. While the earliest crust must necessarily have been in the nature of a fire-formed slag, that has long since disappeared — unless under the deep sea — and the isogeothermal planes of fusing temperature have gradually encroached on the later formed strata, in order to maintain the thickness of the crust at the value required by the conductibility of the materials and the difference between the external and internal temperatures.

14. The discussion of the question whether certain rocks are to be regarded as of igneous or of aqueous origin, has occupied too much attention. There must always, since the descent of the ocean, have been rocks in formation along the zone where fire and water were contending for supremacy. That zone, as I have stated, has gradually ascended, in consequence of the thickening of the crust on its exterior. So far, however, as the general refrigeration of the earth has progressed, that zone has been lowered. Through the zone of conflict, fire and water have both left their traces. In the higher planes, the action of water has been most conspicuous; in the deeper planes, heat has acted most energetically. Chemism has been everywhere present to accomplish what the conditions permitted in the breaking up of old molecular structures and the creation of new ones. Every rock-aspect within the zone of conflict has originated both aqueously and igneously. There has been no exclusive origination by the action of dry heat or by the action of water — save in those wandering dikes, which have brought sometimes, into the disputed zone, or even into the domain, of aqueous activity, the conditions which normally obtain only in the exclusive domain of igneous action. If we could truly picture the state of matter in the deep, water-soaked and centrally-heated zones of crust, we would see the old but genuine sediments softening into a paste, undergoing a powerful digestion, their molecules, loosened from the ancient ties which bound them, all astir with movement in the search for new affinities; new-formed mineral combinations growing into being, and adjusting themselves in the structural frame which the decaying sedimentation-lines arranged for them, undergoing finally, a total transformation, so that no particle of the primitive sediment remains, though the reminiscence of it is visibly built into the design so conspicuous in the plan of foliation which supervenes.

§ 32. ECONOMIC PRODUCTS.

As the survey has been a strictly general one, no special attention has been given to economic results. What I have to offer, therefore, is merely collateral.

The mineral resource of chief interest at the present time, and probably the one of chief importance, is iron. I have said all that is necessary at present regarding the geological position of the iron ores, their mode of occurrence and the principles of search. Further and more special treatment will be left to other hands. I propose simply to enumerate here the localities at which I have myself observed indications of iron ore, and also those of which I have learned by report. The following localities show my own observations arranged according to halts: In the second column are the localities known from information:

4.	Sec. 20, T. 62-15.		Sec. 8, T. 62-14.
23.	Sec. 13, T. 62-14.		Sec. 4, T. 62-14.
26.	Sec. 14, T. 62-14.		Sec. 20, T. 62-14.
27.	Sec. 15, T. 62-14.		Sec. 21, T. 62-14.
29.	Sec. 15, T. 62-14.		Sec. 22, T. 62-14.
39.	Sec. 36, T. 62-14.		Sec. 23, T. 62-14.
60.	Sec. 19, T. 62-14.		Sec. 13, T. 62-14.
61.	Sec. 19, T. 62-14.		Sec. 18, T. 62-12.
63.	Sec. 27, T. 62-15.	Tower Mines.	Sec. 17, T. 62-12.
64.	Sec. 27, T. 62-15.		Sec. 16, T. 62-12.
65.	Sec. 27, T. 62-15.		Sec. 27, T. 63-12.
66.	Sec. 27, T. 62-15.		Sec. 22, T. 63-12.
145.	Sec. 20, T. 63-11.		Sec. 22, T. 63-11.
174.	Sec. 29, T. 63-11.	Silver City.	Sec. 23, T. 63-11.
176.	Sec. 29, T. 63-11.		Sec. 24, T. 63-11.
229.	Sec. 27, T. 63-11.		Sec. 25, T. 63-11.
286.	Sec. 30, T. 63-11.		Sec. 13, T. 63-11.
287.	Sec. 30, T. 63-11.	Eaton & Merrit (originally).	Sec. 8, T. 62-13.
288.	Sec. 30, T. 63-11.		Sec. 5, T. 62-13.
296.	Sec. 18, T. 63-11.		Sec. 4, T. 62-13.

The sericitic and argillitic slates of the region yield roofing materials of excellent quality and of two principal colors. Some of the most favorable localities for quarrying are at Halts 479 and 485. These are both in Moose lake. The former are of a bluish-gray color, and great tables ten feet square are found weathered out and successfully resisting the action of frost and the atmosphere.

Good flagstones of mica schist, silicious and evenly bedded, are found in Farm lake at Halt 228. Similar stones are found on Burntside lake at Halt 82.

Scythe-stones of good smooth, even quality occur at Halt 82, and again at Halt 92, in Burntside lake.

A fine smooth whetstone material is found at Halt 773, at the portage out of Delta lake. It is a silicious slate. A very similar slate is found at Halt 774, at the portage out of Epsilon lake.

A fine architectural stone, capable of a beautiful polish, occurs at the south end of an island in Burntside lake. It is Halt 106, and the rock is a diorite or hyposyenite, with lustrous black hornblende and a pink feldspar. A beautiful syenite suitable for outside constructions occurs at Halt 886. This is of medium grain.

A handsome rock for inside architecture is the chloritic sericitic schist at Halt 566 in Ensign lake. The chloritic constituent is bright green and gives the rock a showy appearance. But, as the rock weathers rusty, it can not be recommended for exposed situations.

No geological improbability exists of the occurrence of ores of silver in some of the quartz veins of the sericitic schists. The pyrites thrown out plentifully in an opening on an island in South Eagle Nest lake might fairly be expected to prove argentiferous or even auriferous. Simply the question of fact remains to be determined.

§ 33. COMPLETION OF THE STUDY.

The field-work remaining within the district here reported on is not extensive. It may be well to examine the north side of Burntside lake from the west end to and through section 16. The two lakes east and southeast of Snowbank lake, one of which is named Disappointment lake, ought to be visited, though I am sure the approach will be difficult. They lie in a region not far from the junction of the southern syenite and the gabbro of Ima lake. Gabimichigama lake requires further study, and Kekekabic, though quite carefully examined, will probably repay a re-examination.

In the wider prosecution of the survey, the field-work should by all means be extended over the region lying east and southeast of Ogiskke-muncie, as far as Lake Superior and Thunder bay.

Before final judgments can be passed on any part of the region, even that here reported on, the whole collection of rocks and minerals should be subjected to careful and competent microscopic examination. Every aid which microscopic research

or chemical analysis can bring should also be summoned into the investigation. All these researches should be carried on in the light of comparative studies in other fields which have become classic in the history of geological science.

If the study of northern Minnesota can be completed in some such manner as here indicated, I believe the result will mark an era of important progress in Archæan geology.

III.

GEOLOGICAL REPORT OF N. H. WINCHELL.

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I. THE IRON ORES OF MINNESOTA.

By reference to the geological map which accompanies this report the statements that follow, respecting the distribution, both geographic and geologic, of the iron ores of the northeastern part of the state will be more easily understood. This map extends from the west end of Vermilion lake eastwardly to the extremity of Pigeon point, including a belt of country thirty-six miles wide from north to south, and about one hundred and forty-five miles long from east to west. Within this area are some townships which have not yet been subdivided by the United States, and no plats of their geography can be obtained. These are mainly left blank. This map is designed to express all that is known, at the present time, of the areal distribution of several grand rock-groups, and to serve as a basis for future exploration and study. It must not be interpreted too closely, for it is apparent that between the points at which personal inspection has been made by any members of the survey, are sometimes intervals in which some changes may take place in the geographic boundaries of which we have now no knowledge, and that these are not therefore represented on this map.

The stratigraphic position of the iron ores of the northern part of the state was indicated in 1885,* in a brief statement in the report for that year. Since that time much private exploration has been carried on, and a season's work has been done by the survey in the country where these ores are found. Much more is known concerning the detailed geological relations of these

* Thirteenth annual report, p. 24.

ores and their parent rock-masses than at that time, but nothing has been learned which invalidates the general grouping then given.

There seem to be three horizons in the strata, in northeastern Minnesota, that have attracted attention for their iron-bearing quality, and there are two distinctly different classes of ore. If these be considered in what may be taken for the descending order the titaniferous ores will come first.

The titaniferous ores. The first examination ever made, so far as known, of this ore in Minnesota, and probably the first in the entire northwest, was done by the survey. The samples examined were from the neighborhood of Duluth,* and the metallic iron amounted to something over sixteen per cent, with quite a notable quantity of titanium. At that time some local interest was awakened over the supposed existence of valuable ore deposits within the corporate limits of the city of Duluth. It is sufficient to say that the excitement soon subsided, when it became known that the ore was likely to run low in iron, and that the amount that was known to exist was quite limited. Besides these facts, the presence of a considerable percentage of titanium would have operated disastrously upon the enterprise, had the discovery been pushed far enough to have been worthy of the name.

In the investigations by the survey which were begun in 1878, numerous instances occurred in 1879, '80 and '81, where the titanic nature of these ores, and their relation to the rocks embracing them, were noted. Samples of iron-sand, from the beach of lake Superior, were gathered at Black beach, near Beaver bay (see survey number 126), weathered out from a rock a short distance from the lake shore. This sand, which is so abundant as to give name to the beach, has the following composition, according to Prof. James A. Dodge:†

Silica	65.17
Titanium binoxide	2.48
Phosphorus	traces
Protoxide of iron	2.23
Magnetic oxide of iron	30.06
	99.94
Total metallic iron	23.50

* Fifth annual report, p. 63.

† "The protoxide of iron was computed as united with 2.48 per cent of binoxide of titanium. I compute how much Fe O is required to unite with the determined amount of Ti O_2 to form Fe O Ti O_2; then I compute what remains of the iron as $Fe_3 O_4$.—[*Dodge.*]

The rock from which this sand is derived is one of the well-known forms of the great gabbro range, an igneous rock which nearly everywhere embraces a greater or less amount of this ore as an original ingredient. In the eighth report of progress the following statement is made concerning this ore:

The iron that is common in this rock seems to be always titaniferous. Very rarely any crystalline forms can be discerned. It seems to have formed in crystalline condition later than the plagioclase and pyroxene. It attaches itself to the poles of the magnet, but yields in decomposition *in situ* a white subtranslucent or opaque substance characteristic of menaccanite.

In the report for 1881 is given the geology of the iron ore found at Mayhew (or Iron) lake on Sec. 36, 65-3. In general it is summarized as follows: It is a condition of the trap of the country, and is almost entirely made up of magnetite. The ore is in the igneous rock, varying in quality very much, even passing into rock that can not be styled iron ore. It involves with itself nodules of coarse gabbro containing considerable magnetite. It also embraces isolated pieces of gray quartzyte (apparently) but which in thin section are seen to consist of plagioclase, magnetite and augite; and some dark, crystalline, micaceous nodules. It has an apparent dip toward the south, in beds whose aggregate thickness is at least fifty feet, but may be seventy-five feet, the actual amount being hid by a swamp. It sometimes gives place to a coarse trap of the same kind, which is so large in amount as to constitute the rock of the place, and its connection with the ore can not be seen. It lies on a fine-grained gabbro, with chrysolite, which resembles a fine granular gray quartzyte. There is sometimes an apparent northward dip, at a high angle, but this is due to a deceptive appearance of columns of basalt. The ore, which is in considerable quantity, is of fine quality so far as metallic content is concerned, and is visible in numerous places in the same vicinity.*

"This iron ore constitutes what is locally known as the Mayhew Iron Range, and is found in a belt about a mile wide on both sides of Iron lake, and on the south side of Portage lake, and between Portage and Poplar lakes." An analysis of this ore has been made by the survey, showing the following composition:

*Tenth annual report, p. 80.

Silica	20.90
Alumina	1.75
Lime	traces
Magnesia	2.63
Titanium binoxide	2.23
Phosphorus	none
Protoxide of iron	2.01
Magnetic oxide of iron	70.29
	99.81
Total metallic iron	52.46

This magnetited trap spreads widely towards the southwest from Mayhew lake, and in several places constitutes bold knobs of iron ore rising above the surface several feet and extending several rods.*

Boulders of magnetic iron ore, containing a notable quantity of titanium, are scattered over the country between Grand Marais and Mayhew lake. These were noted first by Mr. E. Le M. Hoare, who made a preliminary survey for a railroad from Grand Marais to Mayhew lake, and who had some analyses made which showed a content of titanium varying from six to thirteen per cent. They were also noted by the writer in 1879 in making a trip across the country from Grand Marias northward.

Since the foregoing facts were ascertained there has been a rapid accumulation of information, much of it still unpublished, which goes to show that the iron location at Duluth and that at Mayhew lake are connected by a continuous rock formation, and that at many other places between those extremes a similar ore has been found. It is always magnetic; it frequently rises in conspicuous outcrop. It is on some of the highest land in that part of the state; it follows the Mesabi range; it is in the gabbro belt, and varies greatly, and often abruptly, in quality, but it exists in enormous quantities.

In the state of New York are titanic iron ores, and they are associated with the "hypersthene rock," of the Adirondacks. This rock in New York has been classed in the Laurentian, but if it be of the same age as the gabbro range of Minnesota, it is

* An analysis reported by Mr. Hause performed by R. S. Robertson, of Pittsburg, Pa., gave the following result:

Silica	2.02
Alumina	2.68
Titanium	12.09
Sesqui-chromium	2.40
Magnetic oxide of iron	80.78
Lime	traces
Phosphoric acid	0.03

very far from being at the bottom of the crystalline rocks, and if it be of the same origin as the gabbro it seems not to be of the nature of metamorphic sedimentary rock.

It should be stated that it is not by any means true that all the magnetic ores of the state belong to the titaniferous class, while it is true that a large proportion of them do. There are some magnetic areas not embraced in the gabbro belt, which have different rock associations, and there is, often, a considerable amount of magnetite disseminated through the hematite at the best known and most valued mines. Such magnetite is not titaniferous, and if found in large amounts it would be very valuable.

There is besides a notable difference in the titantiferous ores. The most conspicuous outcrops of these consist of a coarsely crystalline black magnetic ore; rising boldly above the surrounding country. The rock association is a typical coarse-grained gabbro, consisting of plagioclase, augite and titaniferous magnetite. The ore seems to grade into this rock insensibly in some directions. In this gabbro rock generally but little, if any olivine can be seen, and the rock is fresh, clean and firm under the hammer. The powdered ore is black.

Other outcrops of this ore, or ore associated with the gabbro rocks, are often in lower ground. The rock is highly magnetic and very heavy, and almost the only discernible mineral associated with it is olivine. The aspect is rusty, from the decay of the olivine; the grain is fine and close, so compact that with the unaided eye the separate grains can hardly be distinguished. While this ore is also generally titaniferous, some late analyses made by the survey seem to indicate that there may be very valuable deposits of this olivinitic ore in the gabbro belt that are not affected at all by this impurity. This ore when crushed has a dark powder, but somewhat greenish, due to the powder of the serpentinous material that results from the decay of the olivine. So far as known, this class of ores appertains to the lower part of the gabbro rocks, and hence lies along its northern edge, but it is possibly distributed throughout the gabbro area.

This rock, and the ore associated with it, seem to compare well with the eruptive serpentinous rock and magnetite of the Iron hill mine at Cumberland, Rhode Island, and they probably have the same origin.

A typical titaniferous magnetic iron ore, besides being apt to disturb the needle of the compass, is distinguished by being

black when powdered, and hard to break, and when freshly broken has a coal-black, but lustrous fractured surface somewhat resembling that of anthracite coal, both in its lustre and in the angularity of the fracture.

Non-titaniferous magnetic ores. There are several well-known localities where the quartz-schist embraced in the same formation as the hematite ores, is highly charged with non-titaniferous magnetite. This is found to occur in the neighborhood of the northern line of the gabbro belt, but not in the gabbro formation. Sometimes these magnetic quartz-schists are closely associated with, and apparently overlain by a diabasic rock, in uncomformable super-position, the schist standing nearly vertical, and the diabasic rock lying over the whole somewhat in the manner of an overflowing igneous rock. The same quartz-schist in other places in the same vicinity is apparently changed to a jasperoid siliceous iron ore of the hematite class, allowing the observer to infer that for some reason, perhaps owing to the greater effect of the igneous rock, there was a greater concentration of the accumulating iron oxide so as to produce magnetite instead of hematite. Such non-titaniferous magnetite seems to be that found in T. 63-11 and T. 59 and 60-14. It is comparable to the iron ore found at Black River Falls, in Wisconsin, and at the western end of the Penokee-Gogebic iron range on the south side of lake Superior. This kind of magnetite accompanies the hematites. It is found, apparently, in all places in the same formation and when it exists in favorable situations, and has sufficient percentage of iron, it has unexcelled qualities as a merchantable ore.

A non-titaniferous magnetite is similar in outward characters to the titaniferous, but has a less lustrous black color, and is apt to act more powerfully on the compass needle.

Hematite ores — Historical. The great merchantable ore deposits of the state, and of the northwest, so far as known, are of hematite, although some of the mines at Negaunee and Ishpeming, in the state of Michigan, have supplied large quantities of non-titaniferous magnetite.

The first official information which the state of Minnesota had of the existence of iron ore in the northern part of the state, was furnished by the late state geologist, Henry H. Eames. Although the work of Mr. Eames in the region of Vermilion lake was directed, in the main, toward the discovery of gold and silver in the numerous "veins" and "leads" with which he found the rock of

the region to abound, his report for the year 1865 contains the following concise account of the region in which the Minnesota Iron company has since opened the wonderful mines of the Vermilion range.

THE IRON RANGE OF VERMILION LAKE.

"The iron range of Vermilion lake is on the east end of the lake, on the stream known as Two River, which is about sixty feet wide. There are two parallel ridges, forming the boundary of this stream, and at the mouth, on each side, are extensive tamarack swamps. This range is about one mile in length. It then ceases, and after passing through a swamp another uplift is reached, from two hundred and fifty to three hundred feet high. The iron is exposed at two or three points, between fifty and sixty feet in thickness. At these points it presents quite a mural face, but below it is covered with detritus of the over-capping rock. On this account its exact thickness could not be correctly ascertained. The ore is of the variety known as hematite and white steely iron, and is associated with quartzose jasperoids and serpentine rocks. It generally has a cap-rock of from three to twenty feet thick. A little to the north of this is an exposure of magnetic iron of very good quality, forming a hill parallel with the one described.

"The hematite iron has a reddish appearance from exposure to atmospheric influence; its fracture is massive and granular; color a dark steel gray. The magnetic iron ore is strongly attracted by the magnet and has polarity, is granularly massive, color iron black.

"The timber here is very abundant and good, of the same class as prevails elsewhere in this region."

In the appendix to the same report Mr. Eames gives several assays of iron ore from the Vermilion range, showing a percentage of iron varying from sixty-five to eighty.

In the report for 1866 Mr. Eames makes further mention of these iron ores, saying that they are quite extensive, and exist in large masses both at Vermilion lake and further toward the northeast, as well as toward the southeast. Those toward the northeast, he states, are of hematite, but those toward the southeast are magnetic.

Furthermore, in giving the geology of Pokegama falls, on the upper Mississippi, he mentions the existence of iron ore as one of the rocks in place on the rapids of Prairie river. In the accompanying appendix he gives three analyses of iron ores taken from the rocks at Prairie river, the iron ranging from 51 to 70 per cent.

Soon after this a systematic attempt was made by Mr. George R. Stuntz to develop the Vermilion iron ore. In company with Mr. John Mallmann and a few laborers he erected a cabin on the

lakeshore at the east end of what is now known as Stuntz bay,* and spent several months making excavations with drills and powder. He produced a fine showing of good hematite ore, and with great difficulty and fatigue he carried a quantity of it to Duluth. It was doubtless from this exploration that resulted the fine museum samples which were distributed by the Smithsonian Institution, mentioned by Prof. A. H. Chester in his report,† exhibited at the Paris exposition in 1867. Mr. J. Kloos also refers to beautiful specimens of the same seen by him at St. Paul, prior to 1871.

The present survey of the state was begun in 1872, and in the various annual reports of progress are references made to the iron ores of the northern part of the state, the first being in the seventh report (for 1878) in summarizing the observations of the season on the geology of the region. Two analyses are given of ore from the Mesabi range and the ores are compared to those of Scandinavia and Russia, as well as to those of northern Michigan.

"For making steel these ores excel, and iron from the Scandinavian furnaces is imported into England for the manufacture of steel. It is highly probable that these iron deposits will not lie long undeveloped. They are in the midst of hardwood timber sufficient for producing the necessary charcoal and the surrounding country is generally fit for prosperous farming." ‡

In the eighth report are given analyses of two samples of ore from the Mesabi range (survey numbers 438 and 441), these being hematites. The metallic iron was found to vary from fifty-three to sixty per cent. On page 103 is a description of the iron ridges on which subsequently were opened the works of the Minnesota Iron company.

In the ninth report (p. 108) is an account of a visit to the original iron locations in towns 59 and 60 N., R. 14 W., where in 1875 some shallow pits were dug under the direction of Prof A. H. Chester in pursuit of the principal iron mass.

In the tenth report special attention was again directed to the explorations that had been made by non-resident capitalists in the iron region of the northern part of the state, and suggesting that Minnesota capitalists ought to look after this matter, and by concerted action retain within the state as much as possible of the

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* The remains of this cabin, largely built of stone, were plainly visible in 1886, when the survey party visited the place.

† Eleventh annual report, p. 155.

‡ Seventh report, p. 23.

profits consequent on the approaching development of these ores. "Eastern iron deposits and eastern furnaces should not be allowed to find it profitable to send their products past our doors when we have every requisite and every facility for producing the same. It would be a thing highly creditable to the regents of the university to be directly instrumental in developing this great industry, and I hope that general attention will be called to its feasibility."*

In the eleventh annual report is published a report from Prof. A. H. Chester, giving important information concerning the geology and the mineralogy of the iron ore deposits of the Mesabi range and of the Vermilion range. This is based on the explorations he made, in 1875 and in 1880, under the management of Mr. Geo. C. Stone, now of the Minnesota Iron company. This report also contains a short statement of views concerning the age of the iron-bearing rocks of Minnesota.

In the thirteenth report is a somewhat extended account of the Vermilion iron ores, and particularly of the developments of the Minnesota Iron company at its various mines, giving the results of many assays and comparisons with the Michigan iron ores; also a discussion of the stratigraphy of the crystalline rocks of the northwest in which these ores are embraced.

The geology of the hematite ores in Minnesota. Near the south shore of Vermilion lake are the mines or openings of the Minnesota Iron company. Since they are closely contiguous, and under one management, sometimes they are classed as one mine, instead of several mines, the workings of one pit directly articulating with the shafting or tunneling of the adjoining pit. These are mostly open mines, though some underground work has been done at several, and particularly at the Breitung pit, and still more will be necessary as the working proceeds.

The country is occupied by a variety of sedimentary and igneous rocks, and by the metamorphic schists that result from changed conditions of the same. In the immediate vicinity of the mines the country rises in the form of two nearly parallel ridges separated from each other about a mile. These ridges, rising about two hundred and fifty feet above Vermilion lake, and about a hundred and twenty-five feet above the surrounding country, are caused by and composed of the iron-bearing strata of the range, and consist of siliceous, reddish jasper, banded with hematite, and of siliceous schists and of greenish magne-

*Tenth annual report, p. 8.

sian schists. The ore is associated with the jasperoid rock, and is closely banded in it, the two being so intimately mixed that the whole belt of jasper rock is considered the ore-rock and is mined as ore. The jasper is seen to change by insensible stages, on the one side to pure hematite, by the addition of more and more of the ferruginous element, and on the other by the withdrawal of the same and the increase of silica, it becomes a white "chalcedonic" quartz, which on disintegration becomes a white granular sandrock, so easily crumbled that it can be crushed in the hand. The grains, however, in thin section do not appear to be rounded by attrition as in ordinary sandrock. There are all conditions of change in this interesting transition, varying both in the color and in the hardness of the rock. The colors vary from scarlet to black, and to white. As there has been a tortuous overlapping and twisting of the formation, these colors run in ribbon-like bands, closely aggregated, but parallel, in very beautiful stripings; and as this rock forms the backbone and the crest of these ridges these parti-colored patches of bare rock are common on the tops of the ridges and gave indication of the valuable nature of the contents of the hills. Four or five miles toward the southeast from these hills is another hill, still higher, known as Chester's peak, composed of similar rocks. There are also smaller areas of the same kind of rock in some subordinate hills, and short parallel ridges that lie between the mines and Vermilion lake, while toward the northeast such rock is known to occur at intervals for a distance of nearly forty miles.

The bedding stands nearly vertical, the dip sometimes varying a little toward south, or more rarely toward the north; but, in a few places, extending sometimes for half a mile or even more, there is so much irregularity in the bedded structure that no dip nor strike can be predicated for the general formation, but there is a congeries of more or less angular masses of rock showing a varying and discordant strike, pressed together so as to make a compact mass, with the edges nearly vertical still.

The most common rock seen in close association with the jasper-hematite ridges is a soft schist which normally is of a light green color, but which in close proximity to the jasper-hematite ridges becomes stained with iron, taking on a darker and darker color of red, until, in contact with the hematite, it is charged with iron to so high a degree that its original characters, both structural and chemical, are almost obliterated. Where it has its normal structure it is finely schistose, the schists running

in a nearly uniform direction, northeastwardly, in coincidence with the general strike of the sedimentary structure, but when it is reddened by the ferruginous rocks, it is not schistose, or is less so, but somewhat massive. It can not be said to be a soft hematite, but its color and grain give it the semblance of a valuable iron ore. Where the jasperoid rocks are not hematitic, however, such contact does not produce this change in these schists. They lie in immediate contact with the jasper rock, their schistose laminations winding about the rounded surfaces and accommodating themselves in their sinuous courses somewhat to the direction of those surfaces, though having a constant tendency to resume their prevailing direction. This greenish schistose rock is probably of igneous origin, and its relations to the jasperoid rocks, filling all their cavities, overlying them unconformably, destitute of sedimentary lamination, holding fragments of transported jasperoid rock of all sizes from that of a pin-head to masses several rods across, not only indicate its later origin but the direction in which it moved in its creeping motion. These transported pieces seem to have been obtained from the jasperoid ridges and carried, locally, toward the north.

This greenish schist, passing into a chlorite schist, and extending many miles over the country toward the east and northeast, shows stages of transition toward the prevailing sericitic schists and the graywackes of the region, most of which exhibit unmistakable evidences of aqueous arrangement in the act of deposition. This interesting fact, which introduces an element of uncertainty as to the extent to which the aqueous characters can be traced, should not be confounded with another interesting fact, or series of facts, viz.: that the jasper rock itself passes into a laminated greenish siliceous sericitic schist showing in its various conditions equally evident proofs of sedimentary arrangement. These schists differ, however, in composition and in structure. The former is schistose by reason of a superinduced structure — the same structure, running in about the same direction always, and pervading all the rocks of the country except those that are too siliceous or too granular, which causes the easy demolition of the rocks and their fissile-slaty cleavage. Sometimes this schistosity is nothing more than a short-fibrous structure, most evident on weathered surfaces, producing an elongation in all the grain of the rock in a uniform direction. This fibrous and schistose structure crosses the sedimentary lamination, at all angles, when the two structures

do not coincide in direction. The latter has, besides this superinduced schistosity, an evident thin lamination, due to a sedimentary arrangement in the act of formation, the laminæ consisting of different materials, or varying proportions of the same materials, and manifested on the weathered surface by stripings of different color-bands. It is a fact that confuses the observer, sometimes, that the verticality of the beds carrying the iron ores and the direction of strike of this structure, are coincident in direction with the fibro-schistose structure of the former schists. The lamination of the thin schists which are a part of the iron-ore formation, and evidently of the same age, may be seen at several of the cuts by the railroad that runs near the mines along the south side of the "north ridge," at Tower. The thin silvery foliated mineral in the sedimentary schists, which are interlaminated with siliceous sheets, is prevailingly some hydromica, but the foliated mineral that gives character to the schists which appear to act like a changed eruptive rock is apparently some chlorite. The former may be correctly styled sericitic schists and the latter chlorite schists. Still this distinction, although a fundamental one, can not be made in all cases, inasmuch as the sericitic schists acquire chlorite from a change in some of the grains of which as a sedimentary rock they are composed.

The jasperoid rock, which constitutes the iron ore, has been designated jaspilyte by Dr. M. E. Wadsworth. It is still a desideratum in the geology of the iron of the Vermilion range to ascertain the stratigraphic relations of this ore in the series of strata that constitute the system. At the mines at Tower it is closely embraced in the windings of the green schist or is interbedded with a reddened sericitic schist, and its actual contact is not known with any other rock. In the west end of the "south ridge" the jaspilyte graduates through gray, fine quartzyte, to a rigid black siliceous slate which stands on edge like argillyte. South of the mines, along the railroad, some interesting cuts show the jaspilyte closely interlaminated with greenish sericitic schist. At this last place the jaspilyte is itself much less ferruginated, and would bear the name of bedded fine-grained quartzyte. In the thicker beds, particularly when they swell out somewhat lenticularly, the red and purple tints appear if the beds are broken. At points further east, as at Garden lake, the ore is associated with a siliceous rock, or quartzyte, and seems to be covered unconformably by a greenish rock, or schist, which is

parallelized provisionally with the greenish schist seen at the mines at Tower. It rises in ridges in a manner similar to the ridges at Tower. The stratigraphic equivalence, however, of the ore deposits at Tower with the ore deposits south of Long and Fall lakes can not be asserted. Indeed there is more reason to infer that they are not strictly equivalent, though they are associated in a group of similar strata and have a genetic relationship.

Origin of the jasperoid hematite of the Vermilion range. The nature and origin of the rock which constitutes the ore has been a prolific subject of investigation and discussion. It has been supposed to have originated as a sediment, in its present condition. It has been pronounced eruptive, and it has been considered the result of chemical deposition, or transformation of sedimentary beds by chemical substitution of iron for some soluble component, or for one that was removable by the known processes of metamorphic change.

Is the jaspilyte of eruptive origin? To the writer there seem to be some structural features that indicate strongly that this question should be answered in the affirmative. The ore has a banding such as igneous rocks have been said to show. It is cross-jointed, in its narrower spurs, and cut into blocks by some cause which has given it a structure that resembles the basaltiform jointage of dikes. It exhibits occasionally offshoots or "feeders," so-called by the miners, which strike away at large angles from the parent mass, these showing some disturbance and unconformable relationship to the inclosing green schist.* But these appearances are, in the opinion of the writer, only pseudo-igneous, and must be explained in consonance with some theory that will also explain very evident signs of sedimentary structure and origin. The evidences of sedimentary origin for the rock, originally, which now is mined as ore, are briefly summarized below. These evidences seem to be incompatible with the theory of the eruptive origin of the ore.

1st. The inter-banding of the jaspilyte (hematite, jasper of various colors, white silica) is exactly that which is seen in sedimentary rocks. The different bands fade into each other across the structure by faint transitional stages. They maintain over long distances a parallel striping such as sedimentary thin lam-

* The igneous features have been set forth fully by Dr. M. E. Wadsworth in a bulletin of the Museum of Comparative Zoology, Cambridge, from examinations made by him at Marquette, Mich. See *Notes on the geology of the iron and copper districts of Lake Superior.* Geol. Series, vol. 1.

inæ do in all fine-grained rocks and clays, but when followed far enough they are seen to taper to points and disappear as their neighbors increase. In its hardened and somewhat carbonaceous state this rock appears rigidly slaty, though still mainly siliceous, and stands on edge much like an argillyte. This slatiness is visible in some places where the tortuosity incident to folding and crushing has not been developed. It is straight and distinct, and is in consequence of the weathering out of some of the softer thin laminæ. It is found north of Tower, near the town, forming some of the conspicuous knobs facing toward the south. These slates are not black, but they are dark-colored, and remind the observer of some of the black slates of the Animikie rocks further east, and were it not for their perpendicular position, and their other relations to the surrounding rock-masses they could be considered their equivalent. This slaty structure is due to a weathered condition of differently constituted bedded materials, and differs from the slaty structure that may be developed in igneous rocks due to their fluidal structure, in that it is straight and rigid instead of undulatory or wavy. Rock No. 893.

2d. The jaspilyte, though frequently, and perhaps most frequently, presenting a sudden and definite transition to the schists, showing a possible igneous origin of one or the other, does not always do so. It is found passing by a series of short alterations into a schist, which, though greenish and easily confounded with the unconformable green schist, is a constituent part of the jaspilyte, or at least of the formation in which the jaspilyte exists. This structure and transition is represented by rock No. 894. It is here accompanied by much pyrite. This is obtained near the Ely mine, where the railroad cuts the formation. In this schist, thus alternating with jaspilyte, there is no sign of "baking," so-called, that is assigned to the red-colored schist at the mines, and the inference is natural and inevitable that the jaspilyte, here seen to be the contact rock on the schist, did not produce the effect of igneous dikes, and that this is the original condition of the mutual co-relations of these rocks.

This interbedding of schist and quartzyte, the latter being somewhat purple, extends along the railroad as far west at least as to the Stone mine where it is again well exposed (see rock samples 919). Here the jaspilyte passes by gradations into the [illegible] In the immediate vicinity are jasper nodules in- [illegible] midst of the schist, red and purple, some of them

five or ten feet long, appearing like quartzose aggregations in the midst of their native sediments. Toward the south, at some little distance from the point at which this interbedding is visible, the siliceous grains are white, instead of purple, disposed in thin sheets.

At the West Ely mine the open pit shows, on the east wall, a sucession of jaspilyte and schist in beds somewhat like the sketch below, Fig. 1.

Fig. 1.

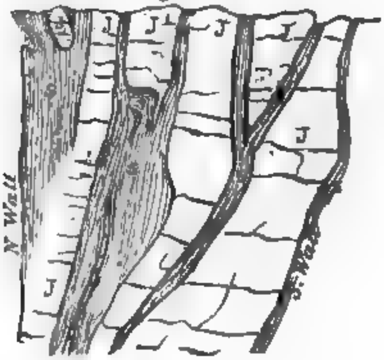

Fig. 1.—*Showing the east face of the open pit at the West Ely mine, and the alternations of schist and jaspilyte.* Width about 50 feet.

At the East Ely mine, next adjoining on the east, the same bedded alternation of schist and jaspilyte is apparent, but owing to the greater development it is brought out more distinctly. The following sketch (Fig. 2) represents the east face of this mine, the observer looking on the edges of the beds. Each one of these beds of jaspilyte has a fine internal lamination which is much contorted. The schists, which are pervaded by a schistose structure when not reddened by iron, and which when reddened are less schistose, and "baked," though soft, do not manifest, so distinctly, a finer internal lamination. The four-inch bed of schist at the left of the sketch runs the whole length of the mine, and even appears on the stripped surface east of the opened pit, running 500 or 600 feet altogether.

At the Stuntz mine the same regular (or irregular) alternation of beds of ore with red shale can be seen, there being visible three schist beds, from six to ten feet thick, dipping N. or N. N. W. about 80°.

That this regular alternation should extend thus for three-fourths of a mile, requires some cause that could open the crust

of the earth in perpendicular sheets, if the jaspilyte be eruptive, and inject equally thin alternating sheets of igneous matter. It is much more like the alternation of sedimentation, followed by upheaval and pressure.

Fig. 2

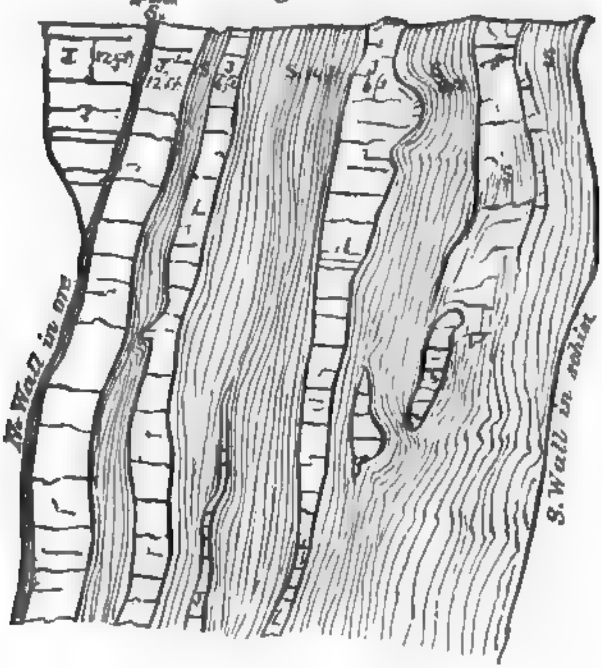

Fig. 2.—*Showing the alternations of schist and jaspilyte at the East Ely mine.* Width about 70 feet.

On the southern slope from the "south ridge" to Tower are some very interesting exhibitions of the relations of the jaspilyte to the schists, some of them showing the minute interstratification of the jaspilyte with the sericitic sedimentary schists, and others exhibiting the manner in which isolated, transported masses of the jaspilyte are surrounded unconformably by a chlorite schist. Of the former the following pen-sketch was made, illustrating a more minute association of the schist and the quartzyte than in figures 1 and 2. The area here represented can be seen to extend, with the strike, a distance of twelve feet, when it fades out gradually by the loss of the siliceous element, and becomes entirely schist. Before this takes place the sili-

ceous bands are interrupted and some nodules and accretions appear in place of the continuous sheets of silica. This quartzyte on the weathered surface is light gray, but on the freshly broken edges shows the jaspilitic colors. The schist is fine and evenly laminated, in its alternations with the quartzyte, and with itself, not being disturbed by coarse sediments, or by faults or contortions. This is one of the most perfect illustrations that has been seen of the manner of transition from the jaspilyte to the schists. Indeed this is not a transition, since nothing but green schists exist on either side of it for a distance of eight or ten feet, as far as the rock is exposed. The diagram shows rather that the jaspilyte is in thin interstratified sheets within the sericitic schists. The sketch does not show, and can not be made to, all the fine interlaminations and gradations between the two, since the schists themselves become arenaceous and gradually lose their green tint, becoming gray, then white, then purple, when broken, and requiring the designation of jaspilyte. The thickest distinct lamina seen here is about one inch, and the thinnest is a mere film and becomes lost in the schist.

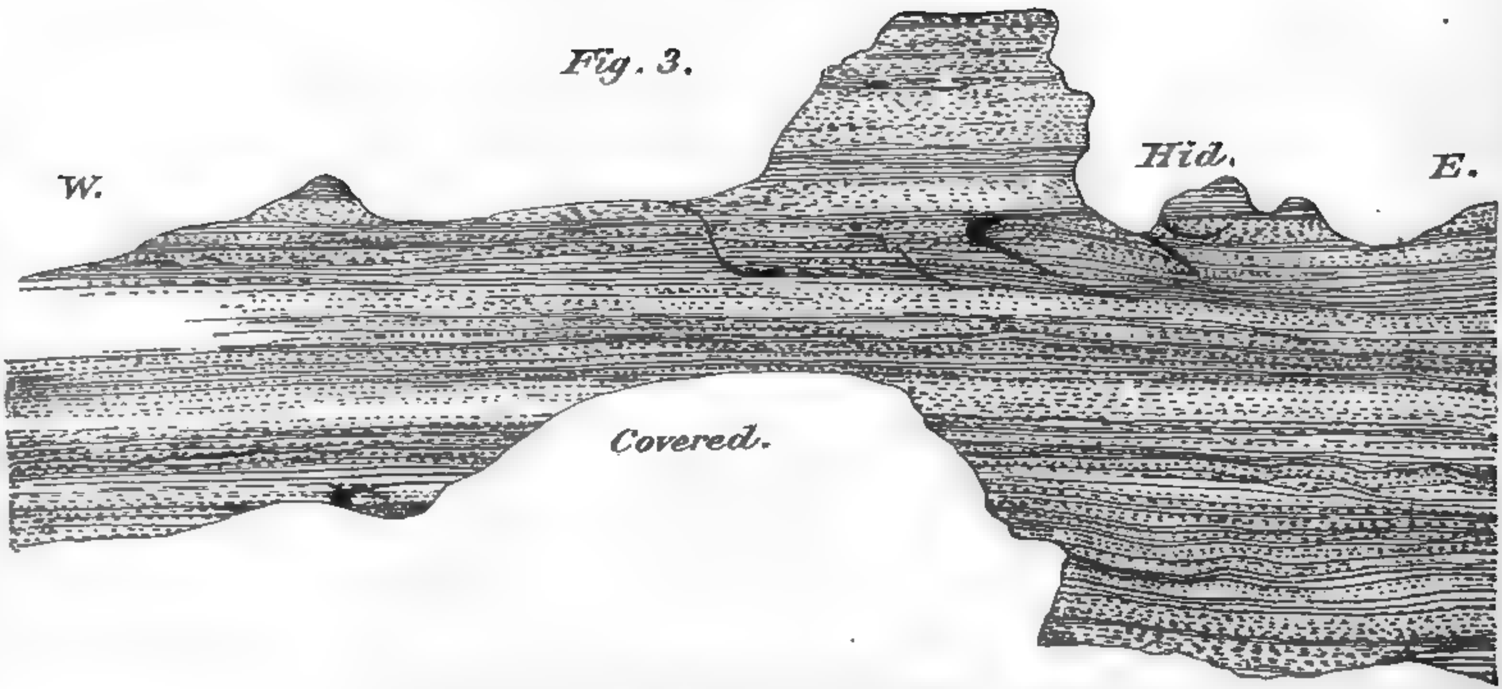

Fig. 3.—*Showing the minute interlamination of jaspilyte in sericitic schist.*

This is a true interstratification, due to sedimentation, since not only does this banding show it, but the schists also show a sedimentary banding. The strike is ten degrees south of west, and the bedding is vertical, or dips at an angle of eighty-nine degrees toward the north. No drawing can do justice to the minute mingling of silica bands with schist bands.

The continuous lines indicate silica sheets and the broken lines indicate the schist. The black irregular patches are intended to show chemically deposited white silica. The distance across the bedding is three and one-half feet, and is exaggerated in respect to the length actually included in the sketch.

Very near this place, about twenty feet north, is a bold exposure of green schists that are supposed to be unconformable on the iron-bearing rocks. These schists embrace irregular masses and arms of jaspilyte, the strike of the prevailing structure being W.40° S., a variation of thirty degrees from the direction of the strike in the schist illustrated by the foregoing figure. The jaspilyte here surrounded by the chlorite schist is represented by rock No. 909.

At a point about fifteen rods east of the place illustrated by figure 3, the siliceous bands do not have the long extension in the direction of the schistose structure which is seen in the figure, but the silica is in fine lumps drawn out in the direction of the schistosity, some of the lumps being not more than a sixteenth of an inch in thickness, or a mere film, and some of them being an inch or two. There is a fine thread-like interlaced mesh of roughness caused by the more enduring silica ingredient standing up on the surface of the weathered schists. In the interstices of the mesh is the schist, some of the areas of the softer rock being inclosed, or nearly inclosed, by the harder, but for the most part prevailing over the harder in one direction, and giving place to more and more of the siliceous ingredient in the other. There is visible here no true sedimentary banding, like that of figure 3, but a dissemination of jasperoid silica through the schist in an irregular manner.* There is no gradation of the schist into the silica, by varying amounts of fine silica mingled in a soft greenish or grayish mud; but the silica, even in the smallest lumps, is pure silica, and the schist does not perceptibly vary in its characters. In one direction, as the silica increases, it forms larger and larger lumps, so that some of them have the characters of jaspilyte, but without the parti-colored

* This point is shown by a photograph made on the spot.— No. 12.

banding. Instead of a banding the colors are in blotches. Still further in the same direction, as the jaspilyte masses increase in size, so as to constitute the most of the rock, they are somewhat banded by alternating colors and sometimes the banding is transverse to the schistose structure. It would seem from these facts that this lumpy silica is due to the dissemination in small pebbles and larger masses, through the molten rock from which the inclosing chlorite schist is supposed to be derived, of the jaspilyte of the iron-bearing rocks; and that chemical and molecular changes incident to the conversion of the massive doleritic rock to the green schist, have given the smaller pebbles a semi-stratified or schistose arrangement in the schist, each mass being elongated in the direction of the prevailing structure; and while the same elongation is stamped on the larger masses, they have not been so affected but that their shapes are better preserved, and their internal structure is still evident.

3d. The schists are not by any means usually *baked* alongside of these jaspilyte belts. This is shown by No. 894, and also by many other illustrations from other points that could be adduced. No. 895 shows a gradual transition between the schists and the jaspilyte, without pyrite, near the same place as No. 894, not from between two jasper belts, but more distant, rather from the general mass of the schist. The contact is most commonly a simple one, with an abrupt transition, or there is a gradual interchange without any appearance of the so-called baking. This gradual transition is most apparent, and most frequent, in other places than along the great jasper belts.

The green schists themselves, at the same railroad cut, seem to become homogeneously arenaceous with the same (rounded?) granular quartz as seen in the jaspilyte—which, if true, seems to require some other explanation besides the theory of incipient disintegration to explain the granular condition of the quartz in the jaspilyte. The theory that the (rounded?) grains were thrown down as a sediment would then be extended rightly over both kinds of rock.

4th. In the non-conformable schists there are what appear to be not only pebbles, but lenticular masses of jaspilyte, or at least of jaspery and chalcedonic quartzyte. These are granular, like all the rest, and easily distinguishable from the secondary or chemically deposited silica. Some are as fine as a pin-head, and do not show much, if any, disturbing effect on the fine laminæ of the schistose structure, and others are somewhat larger, and

larger, and larger, and produce some warping of the laminæ, the warping extending further and further from their surfaces as their size increases. These minute pieces of jaspilyte are of the same character as the larger masses, and must have had the same origin. But they are so numerous that thousands may be embraced in the area of a square foot. They are sometimes distributed amongst the schist rather uniformly, and sometimes they are crowded about some of the larger masses. There is also, occasionally a coarse breccia, with small and large, rounded and angular pieces of the jaspilyte, all embraced in a sparse matrix of green schist, resembling somewhat a conglomerate. The inference is natural, and inevitable, that these jaspilyte pieces could not have been introduced as eruptive matter in the green schists, but must have been coincident in time with the advent of the schist. Their original, first formation, and their source, would still be a matter of further investigation. These fine jaspilyte pebbles are seen in rock Nos. 897 and 889.

5th. The hematite can be seen in some places, where favorable circumstances have conspired to preserve the structural relations. to acquire the finely bedded or laminated, or banded structure seen in the coarser bands of the jaspilyte. This is particularly visible where the hematite is specular—indeed the specular structure is due to the cleavage off of large surfaces of the ore along these lamination planes. In other places this fine striping is seen to fade out both longitudinally and transversely into a massive, hard hematite. This does not show, perhaps, that this banding is not a fluidal structure due to the eruptive nature of the rock, but it shows exactly the structure that would be expected in the rock if it were all of sedimentary origin—at least the jaspilyte—and it seems to indicate that the iron-ingredient is not of the same origin nor date as the siliceous jaspilyte, but of later date, since it partially or wholly obliterates the characteristic fine lamination of the jaspilyte. When it does not totally obliterate it, it accommodates itself to that structure. This is represented by rock 905.

6th. There are places, not common, where the iron ore seems to be a breccia of jaspilyte and "baked clay," or, more likely, a highly ferruginated and hardened clay. There are all stages of ferruginization; some of these breccias not constituting ores, and others affording a lean ore. Generally they are better ores when associated with the large jaspilyte belts, and poor when in small patches. These breccias are supposed to form a constitu-

ent part of the iron-bearing strata, and should not be confounded with those conglomerates made up by the mingling of transported masses of jaspilyte in the unconformable green schists. This ferruginization of fragments of both jasper and clay, in a breccia, seems to show that the iron, as an ore, is not necessarily a part of the jaspilyte, and this idea is borne out by the fact that the ore of the Gogebic range is one that consists largely of a breccia of some soft rock. If then the hematite is not essential to the rock known as jaspilyte, the residue would be almost entirely silica, and it is a novelty to suppose that pure silica could ever have been injected among the rocks of the earth in the form of igneous dikes.

7th. When this silica, which has been styled chalcedonic, interleaved with the hematite and jasper, is weathered, and finally disintegrates, it crumbles into a fine white sand, the grains being of uniform size. It is then friable like the St. Peter sandstone, and could be used for scouring and polishing. If a large piece of such weathered "chalcedonic" silica, carefully selected, be thrown down on the face of the firm jaspilyte, it is crushed with a dull explosive noise, the individual grains of silica flying from the point of impact in all directions, the phenomena being the same as when a slab of soft sandrock is thus thrown down on a hard surface.

On the contrary, when a piece of the chemically deposited silica, taken from some of the veins with which the country rock is everywhere intersected, is thus treated, howmuchsoever it may be weathered, it is either splintered into sharply angular bits of various sizes, or is simply crushed into white powder on some of its corners. In this the white "chalcedonic" silica behaves like the quartzytes at Pipestone and New Ulm. They are also sometimes vitrified superficially and very hard, with the appearance, including the color, of much of the fine quartzyte seen in the jaspilyte, but when disintegrated by the atmosphere they dissolve into a homogeneous white sand. This granulo-friable disintegration is shown by rock numbers 899 and 900.

8th. It is apparent at many places about the Vermilion mines that the great mass of the iron formation (the jaspilyte) is conformable with the schistose structure of the schists that inclose it. It is absolutely conformable with the schists that are, at some points, a little removed from the mines, interstratified with it; and, in a general way it is conformable with the structure of the unconformable schists. On the supposition that the jas-

pilyte be igneous these schists also would have to be considered sedimentary, and this schistosity would have to be taken for the sedimentary structure,* the unconformities, wherever they exist, being due to the fracture of the beds and the introduction of the fluid jaspilyte. Now in order that such a conformability should exist *at the time of accumulation of the sediments*, on any hypothesis, the jaspilyte must have been introduced at the time of such accumulation and while the sediments were yet soft; and that, on the igneous theory, would not account for the angles and arms and "dikes" that Dr. Wadsworth has illustrated at Marquette, running across the sedimentary structure of the schists; and would require that there should be, besides, a marked difference, even now, in the upper and lower surfaces of such inflowing igneous strata, such as we do not see.

9th. If the jaspilyte be supposed to have made its advent after the sediments were hardened there is no other way but to resort to the igneous theory, and then we have many diffculties, viz.:

(*a*) Why should it appear always at the same, or nearly the same, geological horizon? No other admittedly eruptive rock does that.

(*b*) Why should it run substantially conformable to the stratification in all the important localities? No other admittedly eruptive rock does that.

(*c*) Why should the bulk of the whole be a granular silica? There is no other such igneous rock known. If it be said that the granular condition of the silica be due to incipient disintegration, why does the same granular condition prevail at the depth of seventy-five or more feet below the surface, as seems to be the fact in the Vermilion mines? —see rock No. 892.

(*d*) How could the oxides of iron coexist with silica at the temperature needed for fusion without chemical union? No other instance is known.

(*e*.) How could the evenly banded, long-drawn-out, almost never-blending layers seen in the jaspilyte, consisting of nearly the same elements in endless alternation (hematite, jasper, quartzyte) be imagined to have been preserved in their tortuous parallelism during such a flow through open fissures? No other such fluidal structure is known. The real igneous fluidal structure shows a *general parallelism* in the structural lines, in a nearly

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* Dr. Wadsworth seems to have so considered it in his paper on the Marquette ores; without, however, vouching for its correctness.

homogeneous rock mass,' but the fine bands separate, cross over, blend and mingle in a general flow, at longer or shorter intervals.

(*f.*) How does it happen that the so-called flowage structure is not parallel with the surfaces of the rock walls, in cases where the jaspilyte enters arms or bands or jogs off in the fissured schists? In no case, in the Vermilion mines, has such a parallelism been seen yet; but, either the structure is entirely lost, or it is confused by many fractures, or runs at various angles, even to perpendicularity, to the walls of such a fissure (as at the Stone mine). In other admittedly eruptive rocks the fluidal structure is parallel to the walls of the inclosing rock — at least is parallel to the direction of the flow.

Some remarkable structural phenomena exhibited by the jaspilyte rock have been appealed to as confirmatory of the theory of its eruptive origin, viz.:

1. The jaspilyte structure cuts off the schistose structure, the latter being assumed to be due to sedimentation. But the schistose structure is not due to sedimentation, but to a fibro-schistosity superinduced on a massive rock by alteration and incipient decay.* It has not been seen non-conformable with a true sedimentary structure.

2. Dike-like projections are seen to shoot off from the main jaspilyte mass, forming large angles with the general strike of the jaspilyte.

One remarkable example of this on the south wall of the Stone mine was photographed. It spurs off diagonally toward the S. W. from the main jaspilyte mass. Its width is about two feet, varying to four feet, and it is visible continuously from the top of the mine downward to the first level, about 45 feet, and, passing under the railroad track, is seen again crossing the schists in the same manner, and in the same direction, entering the wall of the next lower level, about 35 feet deeper. This "feeder" is jointed horizontally as well as perpendicularly. It consists of siliceous hematite, and does not show distinctly the banding of jaspilyte. It is splintery in the direction of its length.

* One of the most instructive instances of such a change is visible on the S. W. ¼ of sec. 21 and N. W. ¼ of sec. 28, 63-11. Rock samples 1017 to 1023.

The plan of that part of the south wall of this mine which embraces this so-called dike is shown by fig. 4.

Fig. 4.

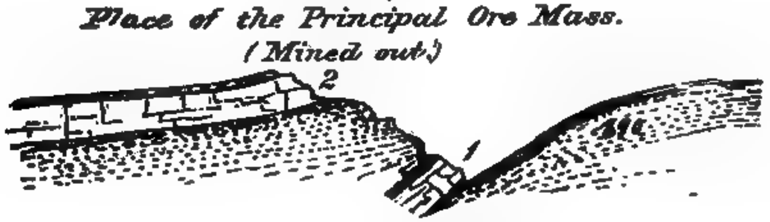


Fig. 4.—*Showing the plan and manner of divergence of the so-called dike, at the Stone mine.*

In this plan the schists are represented by the dotted lines. Nos. 1 and 2 are two beds of ore. No. 1 is the "dike" which is again represented in figure 5, as it appears on the face of the south wall. The schists are charged with iron peroxide, and are entirely destitute of the usual fine schistose structure which pervades them at points remote from the mines. They are coarse-grained, finely jointed with irregular fracture-planes, or are massive and coarsely jointed, similarly to the jointage of the ore. In the close vicinity of the divergent dike they are much confused by close and irregular fissure planes.

Fig. 5.

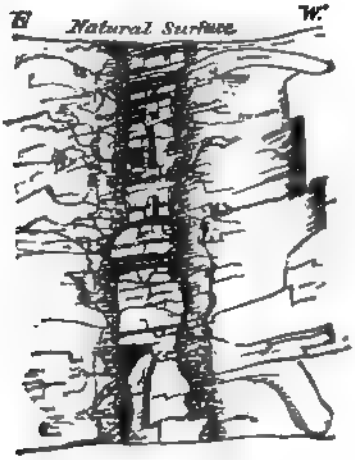


Fig. 5.—*Showing the face of the south wall of the Stone mine where the hematite spur enters it.* The proportionate width is too great. The perpendicular hight is forty-five feet

No. 2 (Fig. 4) is a bed of ore that was separated from the principal mass of jaspilyte and in the operation of mining it was abandoned for about six rods, but was entered upon again at a short distance to the left of the part included in the plan It seems to have been separated from the main mass of ore by a ferruginous schist-scale, about a foot thick, and its broken-off ends have much the appearance of another "dike" entering the schist. Indeed, it was so interpreted at first, but on further examination the two ends exposed were found to belong to the same "feeder."

These features are not unexplainable on the theory of the sedimentary origin of the rock which now holds the ore. It is only necessary to make examination of the other rocks in the vicinity of Tower to discover that the formation that carries the ore has been greatly fractured and pressed together. The fact that the sedimentary bedding, in nearly all cases, stands now nearly vertical demonstrates that there has been applied to the earth's crust, in this part of the state, an immense lateral pressure. Although the strike of the formation indicates that the greatest pressure was in a direction a little west of north throughout a great area, yet it is evident that the direction varied, and that such variation occasioned fractures, and lateral tilting in directions different from the prevailing one. There are large areas where there must have been exerted a great crushing force at right angles to that which produced the present prevailing direction of strike. This may have been chronologically coincident, or nearly so, with the other, but there is no evidence, so far as known, to demonstrate that this endwise crushing of the strata was occasioned at the same time with the tilting. The tortuous infolding of the jaspilyte upon itself is paralleled in the argillytes and graywackes. The onthrusting of these two rocks upon each other, and the protrusion of elbow-like angles from one into the other, producing dike-like tongues and prolongations, are wonderfully exhibited in many places in sec. 20, T. 62-15, and in some places near Tower. The following sketches made on the spot, as well as some others that were photographed, illustrate the manner in which the graywacke and the argillyte are mixed, mechanically, with each other. These seem to prove that the local transportation of the sediments of one bed transversely across the strike so as to lie unconformably among the laminæ of other beds, is not a feature confined to the jaspilyte and sericitic schist, and does not necessarily indicate that either

of the rocks is of igneous origin; but that such breaking up of the formations was a fact that affected all the beds of that age. Some of these figures bear a resemblance to some that have been given by Dr. Wadsworth to illustrate the relations of the jaspilyte and schist at Marquette.

Masses of coarse graywacke are included in a paste of fine graywacke. Such masses are of various sizes, and are sometimes rounded, and so welded with the matrix that no line of contact can be seen. In other cases they are angular. They are seen also to be placed among the argillitic slates — though more rarely — and the argillitic slates are frequently seen strewn in angular fragments from the size of a goose quill to that of a peck measure, through the coarser graywackes, still retaining the striping of fine sedimentation and showing the feathery fracture that such slates exhibit at their broken ends. These pieces of argillyte lie both transverse to and coincident with the sedimentation of the graywackes.

Sometimes the broken off end of a graywacke stratum will appear to have been thrust diagonally into the sediments of an argillyte stratum, or a splinter from one or the other will extend like a dike, or vein, a few inches, or a foot, into the otherwise homogeneous structure of the entered rock. In some cases, and especially in the case of graywacke, folded loops, a foot or even three feet long, carrying more or less of the adjoining laminæ of the argillyte, protrude boldly across the general structure, particularly across the sedimentary structure, the protruded mass being but a few inches in width.

Fig. 6.

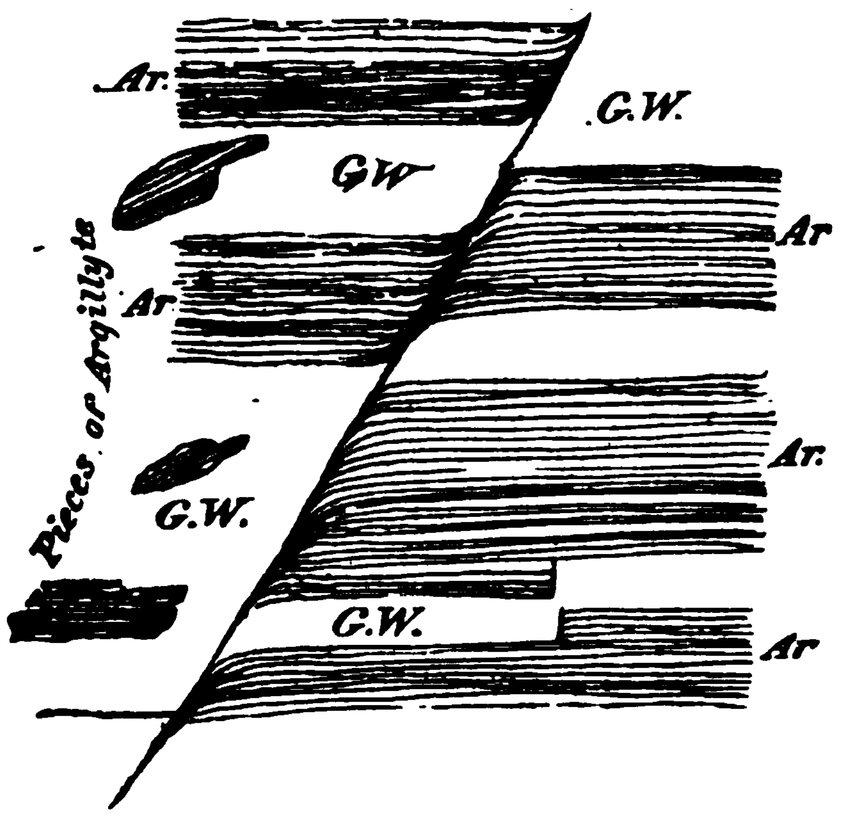


Fig. 6.—*Showing a fault crossing beds of argillyte and graywacke, along which was a contact plane, and a lateral movement so as to warp the beds in opposite directions on the opposite sides; also showing isolated pieces of argillyte in the midst of otherwise uniform graywacke.*

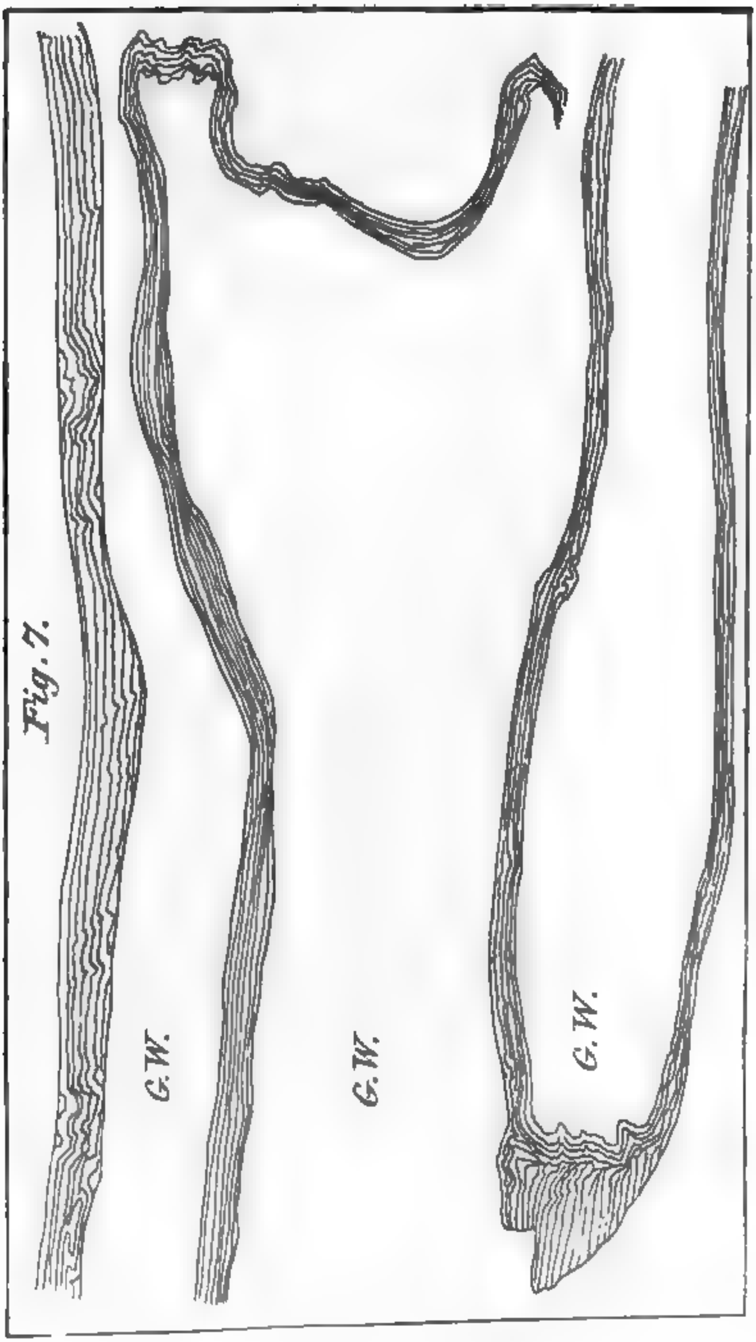


Fig. 7.—*Showing a winding dike of argillitic slate cutting a bedded, but very uniform, graywacke rock.*

On sec. 20, 62-15, the graywacke becomes coarser, with arenaceous grains,and gradually assumes the character of a fine jaspery conglomerate in which the pebbles are arenaceous quartzyte of a somewhat amethystine hue. These conglomerate beds are from an inch to twelve inches in thickness, and alternate regularly with argillyte, following the latter in all its tortuosities. It is twisted back and forth, broken, folded, and "shortened."

In some places it becomes very coarse, and, by the longitudinal shortening it is made to swell out in lenticular, or in very irregular bunches, the fine pebbles being mingled with the coarser ones. The pebbles are from the size of a mustard-seed to peas, and also larger, and the matrix is a green, soft schist which, also, is undistinguishable from argillyte in some of its stages of change. In those places where the aggregation seems to have taken place laterally, perhaps since the first deposition of the beds, the pieces are coarser and the cementing rock is not so commonly and so plainly the soft green schist mentioned, but is siliceous. Most of the pebbles are jasperoid rock, but occasionally there is one of different rock. These latter are found in the coarser portions.

In other places, in the graywacke, are seen some pebbles, two or three inches in their longer diameter, of the same kind of rock as the pebbles in the conglomerate of Stuntz island, mingled with these fine jasper conglomerate bands. Sometimes these pebbles, much finer, make really the most of the fine conglomerate. Such conglomerate bands, however, are narrow, and not common here.

Fig. 8.

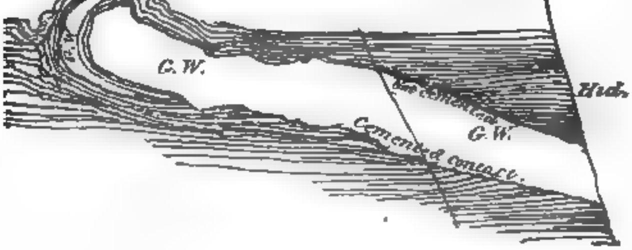
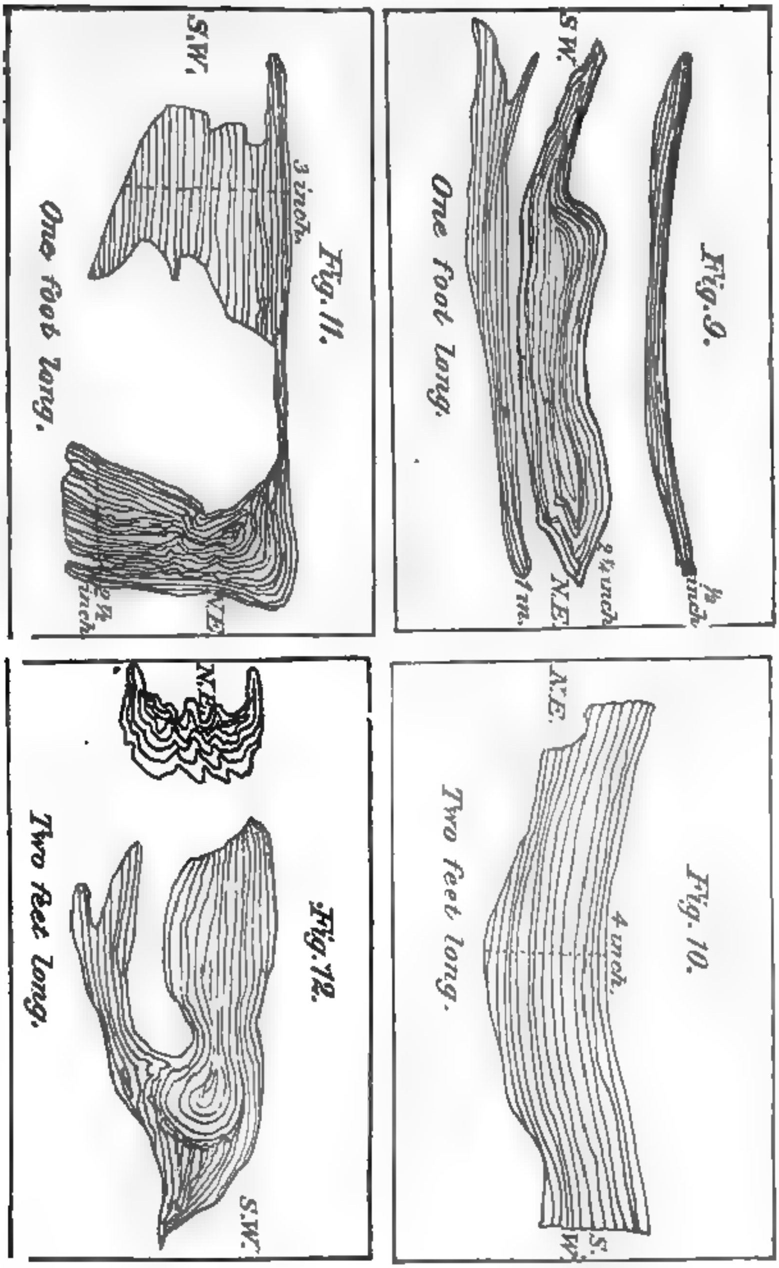


Fig. 8.—*Showing the manner in which a spur or "dike" of graywacke is thrust among the argillyte slate.* This is exposed on the surface of the rock eight feet, and is about six inches wide.

The crumpled condition of the slates at the end of this tongue

of graywacke indicates a forcible protrusion of the latter within the former. The same is indicated by the non-conformity of the graywacke with the sedimentary banding of the slate.

Figures 9, 10, 11, and 12 illustrate the manner in which isolated pieces of the slate are disseminated in the graywacke rock. In all these figures the lined portions represent argillyte, or argillitic rock, embraced unconformably in the midst of coarse-grained wackenitic rock, the sedimentary planes of the former running as shown by the lining.



Figs. 9, 10, 11, and 12.—*Showing isolated crumpled pieces of argillitic slate disseminated unconformably in graywacke.*

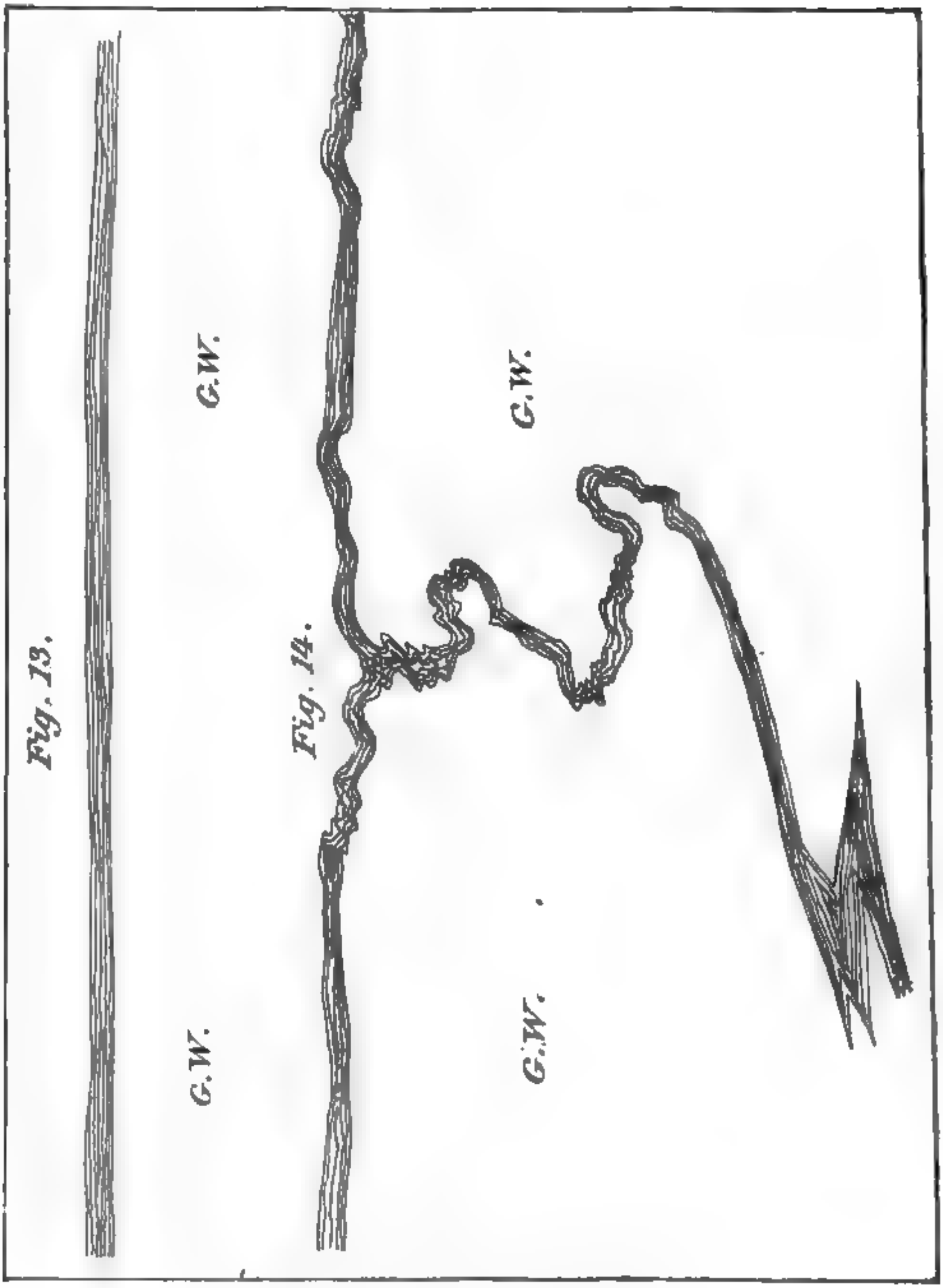


Fig. 13.—*Showing a straight argillitic band in close proximity to a crumpled one*— The latter seen in fig. 14.

Fig. 14.—Showing crumpled argillyte protruding into graywacke. This has a fluidal structure (so called) parallel with the walls.

Figures 13 and 14 are sketches of argillitic rock, running through graywacke rock, one belt being nearly straight and one crumpled. The straight one is about 5 feet long, and an inch and a half in width. The inclosing rock is graywacke in which no distinct bedding is visible.

Other similar sketches could be reproduced. One sketch in my note book shows a band of coarse graywacke, four inches wide and thirty feet long, running across the schistose structure, but rudely parallel with indistinct contorted bands of argillyte, or rock intermediate between argillyte and the graywacke of the band. This narrow band is looped repeatedly back on itself, in a close serpentine manner, some of the folds being so narrow and abrupt, where it was thrust back on itself, that the continuity of the band was broken and the short intervals were filled by the surrounding argillyte. Such fracturing, and thrusting of the "buckled elbows" of one stratum across those adjoining, on one side or the other, will account for the dike-like action of tongues and stringers of ore and jaspilyte which at the mines have the aspect of eruptive protrusions, if not for all the similar facts delineated by Dr. Wadsworth at Marquette.

These figures are intended to show that it is not an uncommon thing to see the firm sedimentary beds "buckling out" in protrusions into the softer ones. In case of fracture, under the process of upheaval, one of the edges of a jaspilyte layer might be protruded many feet into the adjoining beds; and when, in the operation of a mine, such a bed were exposed perpendicularly in the wall, it would at once suggest the eruptive origin of the bed, and inferentially of all the jaspilyte of the region. The same inference, however, would have to be extended, on the foregoing evidence, to the argillyte and the graywacke of the region, and indeed to all the rocks of the series, and they would all have to be pronounced eruptive.

Was the jaspilyte deposited as a sediment in its present condition? It is only necessary to call attention to a few facts which seem to afford a negative answer to this question. The region, and all the rocks of the region, have undergone a long succession of geological changes. The beds are upturned, nearly everywhere, to verticality, and have been folded, crushed upon themselves by pressure, heated by outflowing molten rock, and by intense chemical action, and permeated by superheated waters and gases. They everywhere bear evidence of secondarily deposited silica, and are recemented, in their fractured planes, by it and by other minerals. They have suffered decay in their long expos-

ure to atmospheric agents, and have been changed from their normal mineral constitution to greater or less depths according to the vicissitudes of exposure or protection. It is but reasonable to expect to find effects of these agents in the jaspilyte as in the other rocks. They are found in the jaspilyte. Many of the structural features that have been illustrated by the foregoing figures demonstrate the profound changes that have taken place in the ore-rock since its first deposition.

There are also mineral and chemical considerations, and facts that are dependent on chemical laws, exemplified in the minute structure of the ore-rock itself, which appear to answer this question negatively. Some of these have been mentioned in considering the jaspilyte as having a possible eruptive origin. 1st. The hematite has a relation to the bedded structure which indicates that it was not a part of the original rock, but was acquired subsequently, and was forced to take such positions and forms as the circumstances of the original rock would permit. 2d. The hematite is in a pure chemical condition, and exhibits crystalline faces and forms. These crystalline forms are mingled with the jaspilyte in innumerable places. They fill cavities or line them. They produce the fine scales that give the ore the characters of specular hematite. The hematite is interspersed with minute crystals of magnetite, and sometimes is largely replaced by magnetite, and sparsely by gœthite. The angular forms of the crystals are seen sometimes scattered through the reddish jasperoid rock, and even in the white quartzyte. So far as known, pure crystalline hematite is never deposited as a sediment. Limonite may be so formed, and it may subsequently be converted by dehydration and concentration to a pure hematite or to magnetite. 3d. The silica of the quartzyte is not in its original condition. It has already been stated that the grains of silica, when the "chalcedonic quartz" is disintegrated by weathering, are not rounded as if they had been deposited by the action of sedimentation. The grains of sand of the St. Croix sandstone are rounded as if beaten about on the bottom or on the beach of the ocean for a long period of time. Yet the chalcedonic quartz, when it is crumbled by atmospheric action, seems to be as uniformly granular as the St. Croix sandrock. It seems probable that the original grains, of which the quartzyte in the jaspilyte consists, have lost their rounded outlines by the deposition of interstitial silica, and that each separate grain acted as a governing centre, causing the inter-

stitial silica to arrange itself under the crystalline law governing each individual, along the axial lines of itself, until all the interstitial space had been occupied. Each grain which had been originally a rounded one became thus an angular one. When decay then operates to loosen these grains from each other, they separate first not from the silica which had thus been accreted to their surfaces, but along the planes at which the various grains in their growth had met each other. This depostion of interstitial silica in the quartz rocks of the northwest has been pointed out by Profs. R. D. Irving* and C. R. Van Hise. Such change in the form of rounded quartz grains has been shown by them to occur frequently, in quartzytes of nearly all the older formations, including the quartzytes of the iron-bearing rocks at Marquette, Michigan, but it has by them been regarded as not applicable to the most of the silica of the jaspilyte, which has rather been considered largely as chalcedonic and amorphous. In the opinion of the writer, however, all the so-called chalcedonic silica in the Vermilion region is granular, and its granular character can be recognized easily in the field, and all the sedimentary silica can be distinguished from the secondary chemical silica by outward visible characters. The "chalcedonic" silica seldom or never appears as a cementing material filling cracks and veins except by mechanical transposition but is confined to its interleaved position, between other beds of the ore-rock. It is not vitreous, but has a clouded translucency. The chemical silica is glassy and is apt to run transverse to all the grain and structure of the rock, filling such openings as had been produced by upheaval and fracture, and is never chalcedonic in the same manner as the fragmental bands.†

Was the ore the result of chemical, or metasomatic, change in sedimentary rock? It is most in keeping with the facts, taken altogether, to attribute such an origin to the ore. The ore, as a mass, embraces sedimentary rocks of varying texture and composition, and throughout it, can be seen the variations of texture and structure that only sedimentary action is known to produce in rocky strata. While this is fully borne out by the phenomena seen at the mines on the Vermilion range, it is equally true of the mines on the Gogebic range, at Negaunee, and at Black River Falls, Wisconsin. It is patent also to any geologist who carefully, or even casually, examines the structure at the small open-

* Bulletin of the U. S. Geological Survey, vol. ii, p. 195.

† See, however, rock sample No. 1013, where chalcedonic silica apparently acts as vein filling This subject needs further investigation.

ings that have been made on the Mesabi range. The nice and fine banding, which can be seen crossing the ore itself in the direction of the strike, as well as the coarser interlamination of sheets of ore with jasper or with quartzyte, the shading of the jasper into white quartzyte on one side and into merchantable ore on the other, the transition of the ore-rock into dark gray quartzyte, and carbonaceous slate (see rock No. 868 A—I.), as well as the conformity of the ore-rock in a general way, with the stratigraphy of the associated sedimentary rocks, are sufficient evidence of the original stratified conformable position of the rock which is the ore of the region, among the strata of the great series.

I have imagined that the hematite, as a superinduced feature of originally sedimentary rocks, had been substituted for some soluble or removable constituent, and perhaps by the removal of lime, since the present position of the strata was acquired, or contemporaneous with the acquirement of that position. The fact which is reported (if a fact) that some of the ore of the Gogebic range in Wisconsin is found to contain a percentage of lime that is counted on in the process of the furnace, seems to show it may not all have been removed there, whereas it seems to have been all removed in the Marquette and Vermilion ores—i. e., if it ever were present in these rocks. It may be supposed that alternating thin bands of fine siliceous sand, fine shale and a soluble limestone could, when the proper chemical agencies were brought to bear, be converted into the jaspilyte with all its banding, the fine sand becoming granular quartzyte, the shale becoming the red and brown jasper, and the limestone the pure hematite; when the shale had some ingredient of carbon it would make the black jasper, or the black siliceous slate (of photograph No. 13). The extreme fineness of all the constituent grains of this rock (the argillitic, the sericitic and the jaspilitic) would suggest the possibility of the accumulation of a fine-grained lime-sediment which would be subject to all the chemical enemies that carbonates encounter. But the relative time at which such a supposed substitution of iron for limestone may have taken place is yet with me a matter of uncertainty.*

It is no uncommon thing to hear the ore deposit spoken of as

* The foregoing paragraph, giving a supposed possible method of substitution of hematite for a carbonate, is copied verbatim from my notebook, bearing date July 17, 1886. Since then Prof. R. D. Irving has published a similar hypothesis, giving many facts to sustain it, in the *American Journal of Science* for October, 1886. (XXXII. (3), 255.) He, however, assumes the original carbonate to have been largely siderite, and that the chemical process was essentially one of "silicification," instead of ferruginization.

a *vein*, among the people and particularly the explorers, in that part of the state. The term is applied by the miners and the proprietors to the ore deposits of the Gogebic range in Wisconsin and Michigan. This is a very loose and incorrect use of the word. The ore deposit is in no case, so far as known throughout the northwest, found to take the form or have the origin of veins. A vein is a mineral deposit filling a fissure in the crust of the earth, the filling being done either by chemical secretions on the walls, or by injection of molten matter from below. In the latter case the term dike is applicable, and generally is used. But where the ore beds exist there have been no fissures in the crust. The ore is not arranged as ores are arranged in true veins. The ore is a changed rock-stratum; and it would be as appropriate to apply the term *vein* to a bed of marble, or a bed of granite, as to give it to the ore-bed.

2. THE IRON MINES AT TOWER.

In the thirteenth report of the survey some account is given of the mines and their products, so far as they had been developed at that time. Since then new facts have been discovered and much information of great interest has been obtained respecting the extent of the ore deposit, its geology, its quality at different places and its prospective value.

The principal active mines are still owned by the Minnesota Iron company, but several new mines have been begun.

Beginning at the most westerly of the mines, a brief description will be given of each, embracing such facts as have been ascertained by inspection, or from the proprietors, and such geological notes as have a bearing on the foregoing discussion. In these descriptions will be made references to the rock samples collected and added to the serial numbers of the survey.

The Lee mine is an east-and-west excavation in the eastern extremity of the *south ridge*. This ridge extends westward from the mine north of Tower nearly to Hoodoo point, and affords very valuable and striking facts bearing on the geology of the region. The excavation is 40 feet deep (June 17, 1886), and has followed the perpendicular quartzyte-jasper-hematite beds about fifteen rods, running westward with the strike of the strata. The open excavation is about 30 feet across, and the bedding is very much brecciated. The walls are the greenish schist (rock No. 869), but they widen out rapidly to the west from the point

where the work is now going on. Indeed the ore-rock is found 100 feet ± south from the schist which forms the south wall of the actual mine. It is very irregularly broken and twisted. It is necessary here to work over a great deal of lean ore and quartzyte rock. The hematite acts as a cementing material filling the crevices, etc., caused by the fracturing of the rock, and also permeating the formation coincident with the strata.

The men are now sinking a shaft to the second level, and have a second open pit about 45 feet across, nearly circular. In this pit, which is in the range of the main jaspilyte belt (or is supposed to be), the rock taken out, 50 feet below the surface, is very largely a breccia of green schist, or soft green rock resembling rather a shale in its conchoidal fracture planes, cemented by iron pyrites. The south wall of this mine, as shown in the upper level, consists of a breccia, or conglomerate-breccia, of jaspilyte and green schist, the former prevailing toward the north, and the latter toward the south. Such breccia, sometimes coarse, and sometimes conglomeritic, is found more or less throughout the Lee mine even in the body of the ore, much of it being worthless as an ore. Compare rock sample 912.

East of the principal active pit is an old opening at a lower level at which work has now ceased, apparently because the results were not good enough. The ore here is the same as at the main opening. The hematite seems to have been deposited in the interstices after the fracturing of the jasper and quartzyte beds, which are indescribably twisted, reversed and brecciated.

On either side of the ore-bearing rock appears the greenish schists (869). These are conformable in direction of trend with the general direction of the structure of the ore-rock, and lie directly in contact with the ore-rock. But they are highly ferruginous for a thickness of a few inches or a couple of feet from the ore-rock. The ore-rock apparently occurs in extended, irregular, sometimes lens-shaped patches in this schist. Taken altogether, however, it constitutes a great ridge or range of hills, and runs for an unknown distance, though the hills sink away into low lands at both ends. Perhaps the word *lenticular* is not exactly applicable here to the main ridge or grand trend of the ore-rock, though it is to some of the patches seen in the south ridge about a mile west of the Lee mine. Yet even here, at the east end of the east opening of the Lee mine, the schists crowd on the ore-rock and so narrow it up that it is soon lost under the drift, the

hight of the ridge also becoming less and less. On the north side this crowding is evinced not so much by a loss of layers in the ore-rock as by a change by which the ore-rock actually beomes greenish, then softer, yet reddish and hematitic and finally passes into the schist. This is in the direction of the strike. A large part of the product of the Lee mine is a second grade ore. Rock samples 871, and 871, A.

The West Breitung mine is not much worked yet, but has afforded some fine ore. This mine is the most westerly in the *north ridge*, yet is but little to the east of the meridian of the Lee mine. Here the strike of the quartzyte is very confused and twisted, there being above the mine (i. e. on the north side), a long stretch of jasper and quartzyte, running upward in the higher parts of the hill, that strikes nearly north and south.

The Breitung mine is quite near the West Breitung. It has been extensively worked, but now it is silent. It consists of a series of deep surface excavations that turn about, return obliquely through underground passages and open out in different directions, following the crumpled directions of the jaspilyte. The ore (i. e. the jaspilyte) is not very good, but much good ore has been taken out of this mine. The deposit is in broken and irregular masses, mingled with the prevailing reddened schist. In one place the jaspilyte seems to lie in heavy sloping layers, separated by a soft or at least an earthy crumbling substance. This is not a true sedimentary, nor yet an igneous superposition. The banding of the jaspilyte stands nearly perpendicular everywhere, or varies locally a few degrees from the perpendicular. It is placed alongside the schists which are sometimes nearly white and kaolin-like (No. 884) and sometimes of a brick-red color. Its line of direction or strike is very tortuous, even more tortuous than the shape of the mine would indicate. Indeed the direction of the minute banding has no relation to the direction taken by the mine, but that which governed the miners was the direction of the general trend of all the mass of jaspilyte. The fine banding sometimes runs at right angles with the general direction of the mine, and this is most noticeable at the place marked *D* on the following sketch of the plan of this mine. The schist here is often curiously basaltified, and covered with slickensided areas, when embraced between masses of the rock. The basaltic structure is sometimes curving, like some seen in the trap on the shore of lake Superior. The working of this mine has not exhausted the ore deposit, nor really developed its

width. This mine, toward the east, is directly contiguous with the West Tower mine. Rocks 884 and 916.

Fig. 15

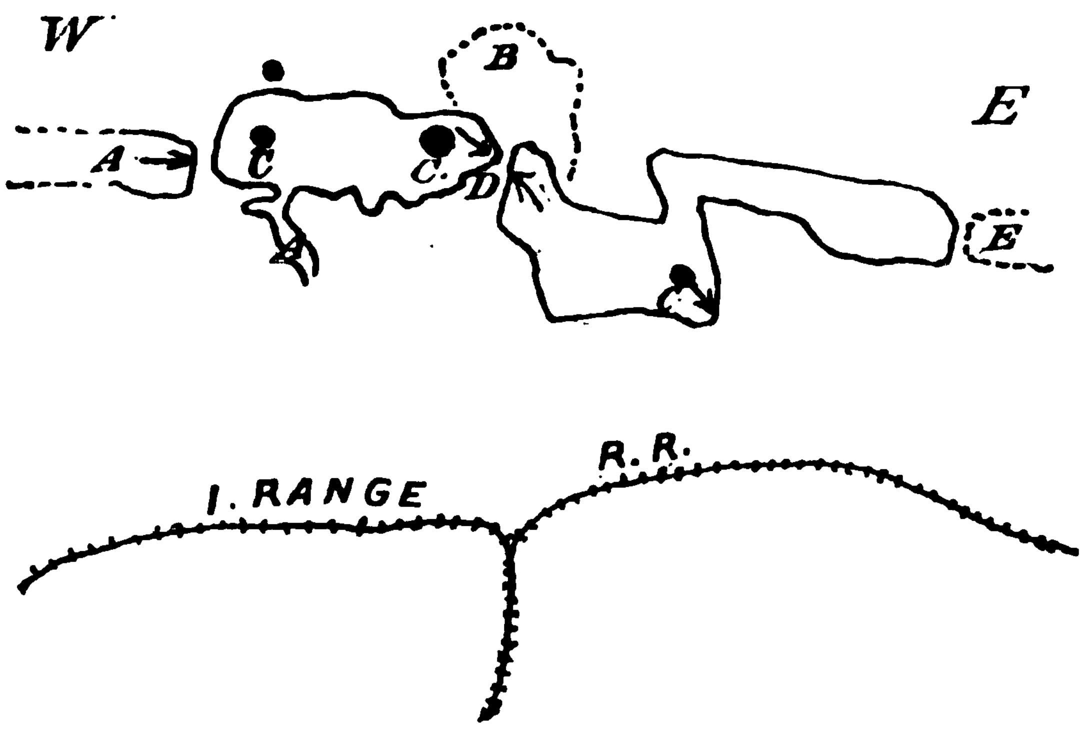


Fig. 15.— *Plan of the Breitung mine.*

EXPLANATION.

A. Cartways.
B. Underground excavation.
C. Deep shafts.
D. Shallow working connecting the two main pits.
E. Beginning of the Tower mine.
→ Mouths of tunnels.

The West Tower mine, in its chief excavation, is an open deep hole, but it has extensive underground chambers through which the product of the mine is carted to the railroad, and by which the different parts of the mine, such as other deep surface openings, are connected with each other. This mine is worked extensively now. The total depth is about 130 feet. The strike of the rocks here is somewhat more uniformly in an east and west direction, but still with much interior banding in the individual layers, in contorted courses. The walls are of jaspilyte, except a small exposure of schist near the east end, in the south wall. It is stated by one of the captains at this mine that the quality of the ore compared to the rock, and the amount of ore, do not change perceptibly as the working gets deeper. This mine is being extended east by a (now) shallow trench.

Fig. 16.

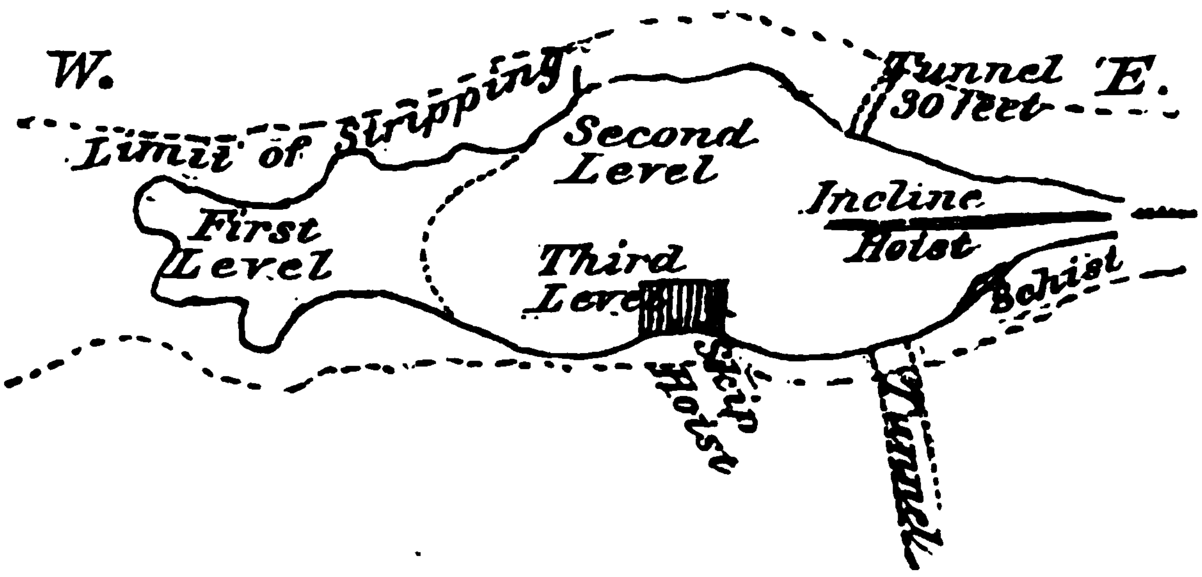


Fig. 16.—*Plan of the West Tower mine.*

The East Tower mine is one of the most productive of the Vermilion range. Four small cars are loaded simultaneously, each one carrying an average load, as stated, of about 5,000 pounds. Four hundred and fifty tons per day are taken from this mine, and seven hundred tons per day from the two Tower mines. Sixteen men are continually shoveling ore into the cars, there being no need of assortment. With diamond drills and steam power, holes are made in the mass of the ore above the level on which the cars run, suitable for a charge of powder. The larger masses too large for handling, resulting from the blasting, are broken by hand sledges, but the most of it is ready at once for loading in the cars. This mine shows the most ore, and the purest great deposit yet found. The walls are entirely in ore. The tunnel running south carries the ore to the pockets which convey it, as wanted, into the railroad cars. The tunnel is cut wholly in green schist which shows a distinct dip north, about 85 degrees (sometimes 80). At the mine the south wall overhangs on the schist; but the work has not gone far enough to reveal the north wall. The product of this mine at present is carried out entirely through the tunnel, without any hoisting. The pit is about 75 feet deep, and 100 feet in diameter, nearly circular. The ore of this mine is represented by rock 876.

Fig. 17.

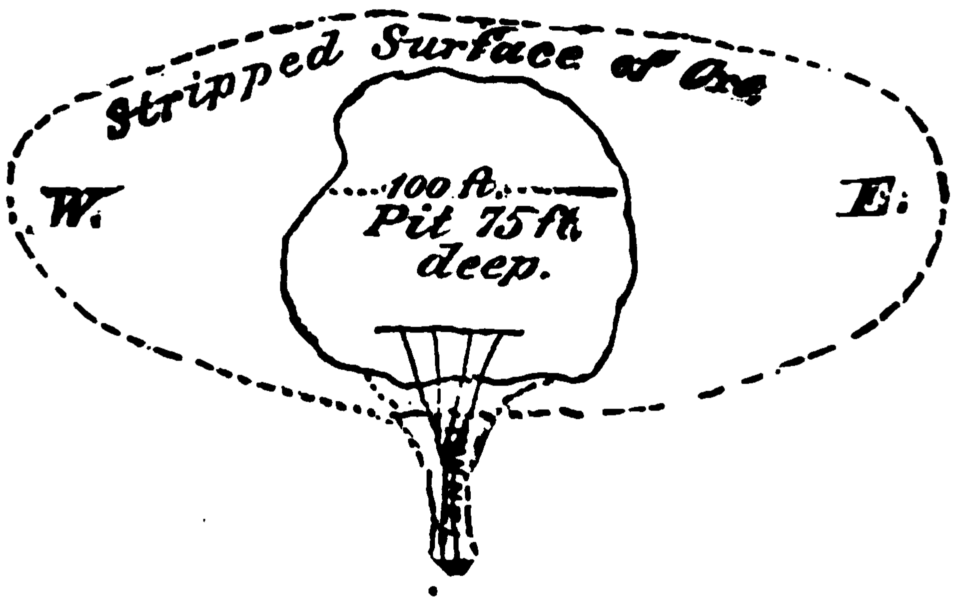


Fig. 17.—*Plan of the East Tower mine.*

The West Ely mine is a simple open pit from fifty to sixty feet in diameter and about fifty feet deep, without having as yet developed a great amount of good ore. The excavated rock is quartzyte and ore, with some schist. The gang of men is small, and the hoisting is done by bucket and horse-power. A sketch of the east face of this mine is seen in figure 1. At this pit the ore is interbedded distinctly from top to bottom, between strata of schist, dipping from 85 to 95 degrees toward the north. No ore has yet been shipped.

Fig. 18.

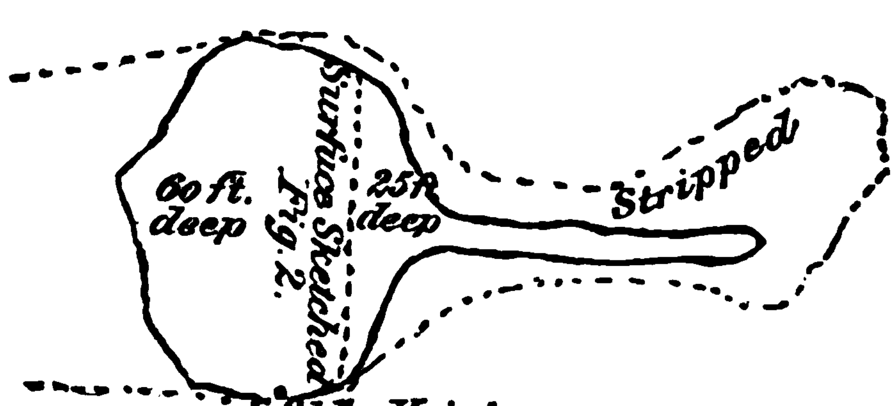


Fig. 18.—*Plan of the East Ely mine.*

At the *East Ely mine* the alternation of ore and ferruginous schist is also distinct. For an illustration of this see figure 2. The dip is the same. The schist and ore are roughly cross-jointed, and in angular blocks, but the ore shows this structure most pronounced. Much work has been done at this mine, and a large daily shipment of ore is made.

Fig. 19.

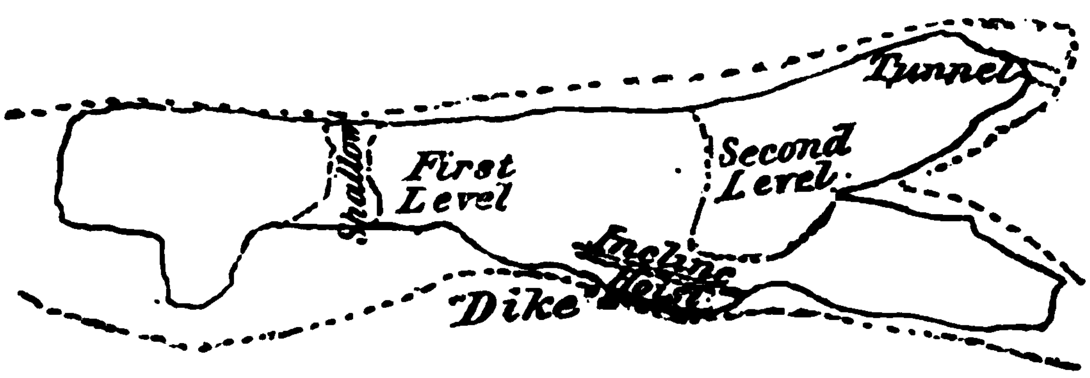


Fig. 19.—*Plan of the Stone mine.*

The Stone mine has been considerably more worked than the East Ely, and consists in the main of a deep trench about forty feet wide, and from forty to eighty feet deep, running about east and west following the course of the main mass of jaspilyte, and about two hundred and fifty feet long. At the east end of the mine the schists, which everywhere constitute the walls at this mine, have a general dip to the north, about 86 degrees. In some places, however, they stand apparently about vertical. They exhibit the hardened, reddened and less schistose, or more coarsely schistose but somewhat jointed, structure which has been attributed to the heating effect of the jaspilyte on the theory that the jaspilyte is of eruptive origin. (Rock samples 890.) This reddened schist seems to have lumps of chlorite, or a chloritic mineral, and perhaps of other minerals, originating in it, as if an incipient recrystallization had been retarded and stopped. In other places this schist shows a similar condition when inclosed between the strata, or belts, of the jaspilyte. Again, in other places this schist is less lenticularly schistose, but, while redder, and jointed more at right angles, it is equally soft. This change in the schist from soft, green, fissile rock, is attributable to the same cause that produced the general ferruginization of the formation, and gave origin to the hematite of the jaspilyte. If it be a baked condition of the schist, the heat necessary may have been derived from the mechanical action of the firm jaspilyte on the schist at the time of the upheaval and fracturing, augmented by chemical action.

The reddened schist sometimes also is banded in a manner similar to that seen in the jaspilyte, and can present a claim, on that account, as valid as the jaspilyte, to a fluidal origin (Rock sample No. 891). There is also, where the sample No. 891 is taken out, a coarse banding in the jointed clay, consisting of more and more, or less and less, ferruginization, parallel to the

banding of the jaspilyte and probably due to the same cause. This, however, is not so marked as in the jaspilyte, but consists of purplish-black, brown, and light-red stripes, the latter being also seen on sample No. 891.

There is a belt, or stratum, on the north side of the mine, at the east end, about a foot thick, where No. 891 is taken out, where this clay becomes firmer and firmer, and even siliceous and hematitic at the centre, where the banding is much more like jaspilyte. This belt increases in importance as an ore, upward, and was taken off, with the operation of the mine. It becomes two belts each about a foot wide, separated by a stratum of red schist.

In this schist are lenticular masses of quartz, quartzyte (these perhaps of chemical origin by segregation), and of banded jaspilyte. These jaspilyte masses are sometimes thin, and interrupted in their courses, and very frequent in their alternations with the schist. To regard them as anything but of original sedimentary origin, though now mechanically, and perhaps chemically segregated into lenticular masses, or pipes, or wavy sheets within the schists, seems impossible and almost absurd. Yet to this *reductio ad absurdum* consequence is the eruptive theory driven, for there is a perfect gradation from the great ore masses to these thin sheets and lenticular masses.

In order to explain this peculiar manner of distribution of jaspilyte, on the eruptive hypothesis, these isolated sheets and scattered lenticular masses, are not admitted to have been isolated from their parent mass, but, before the opening of the mine, are supposed to have been connected with the great jaspilyte lode, such connections now being destroyed by the operation of the mine. Thus they are supposed to have come, at the same time, from the same deep source as the rest of the jaspilyte. It is obvious that from the nature of the case, when one of these is seen inclosed in the schist, one end, or one edge, is seen uncovered, and that end, or side, in Dr. Wadsworth's opinion, had a connection with the parent mass. It thus makes no difference from what direction these are viewed, from above, below. from the right or left, there is no demonstration of their entire lenticular inclosure in the schists, however patent it may appear. When they terminate on the surface of the weathered jaspilyte, before the working has begun, they can be said, safely, to have a deep-seated connection with the main mass. When the mine is opened, and such lenticular masses are found to taper

out downward, and to be overlapped to the right or left by others, an intelligent captain could observe the facts and bring evidence pro or con as to the actuality of their supposed union with the main lode. This question was asked one of the foremen at the Stone mine, in the presence of Dr. Wadsworth. He said they frequently ran out to points downward and ceased to be of any value as ore. But subsequently he told Dr. Wadsworth that they never do.

The following sketch, Fig. 20, shows a lenticular mass of jaspilyte at the east end of the Stone mine, inclosed in contorted and more or less "baked" schists. The end exposed, which faces west, is supposed, on the theory of Dr. Wadsworth, to have been connected with the main body of ore, which now has been mined out. This can not be denied now, and seems plausible from the fact that toward the east this branch of the main ore deposit became narrower, and so unimportant that the work in that direction finally ceased, the running of it out being in keeping with this lenticular mass. The sketched mass is about four feet long perpendicularly, and thirty-five feet below the natural surface of the ground.

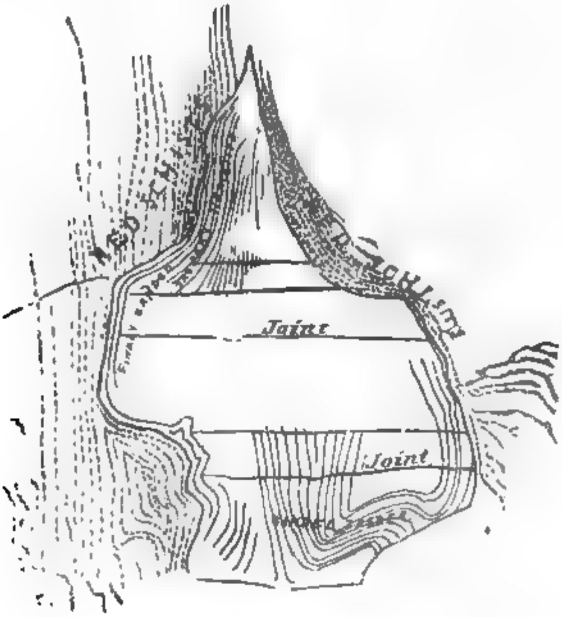


Fig. 20.—*Lenticular mass of jaspilyte in reddened schist at the east end of the Stone mine.*

In the Stone mine, near the north wall, about seventy-five feet below the natural surface of the ground, is what appears to be a lenticular mass of jaspilyte, lying between schist, on the north side, and a contorted band of hematite, on the south side. The lower portion of the rough hematitic rock has been quarried away. Owing to some sinuosities in the line of excavation the profile of this part of the north wall shows the relation of this jaspilyte to the schist and to the rough nodular hematite, as in the figure below (Fig. 21). This jasper (No. 892) is apparently granular in the same manner as that at the natural surface, having, in its whiter portion the same clouded translucence; and this would indicate that the usual granular condition is not owing to incipient decay.

Fig. 21.

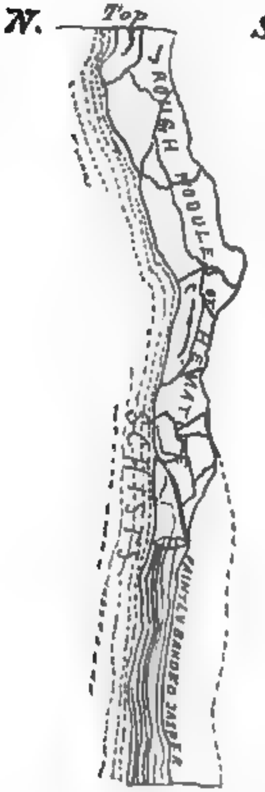


Fig. 21.—*Clouded translucent or "chalcedonic" jasper seventy-five feet below the natural surface, in the north wall of the Stone mine.*

In the Stone mine, near the place of the last, but on the opposite side, is a broken and angular condition of the jaspilyte, now being mined. This is about 80 feet below the surface, and the sinuous course of the banding is shown by Fig. 22. When this rock, so mined, separates in the planes coincident with the sedimentary lamination the cleaved surface is specular, and the ore is specular hematite.

Fig. 22.

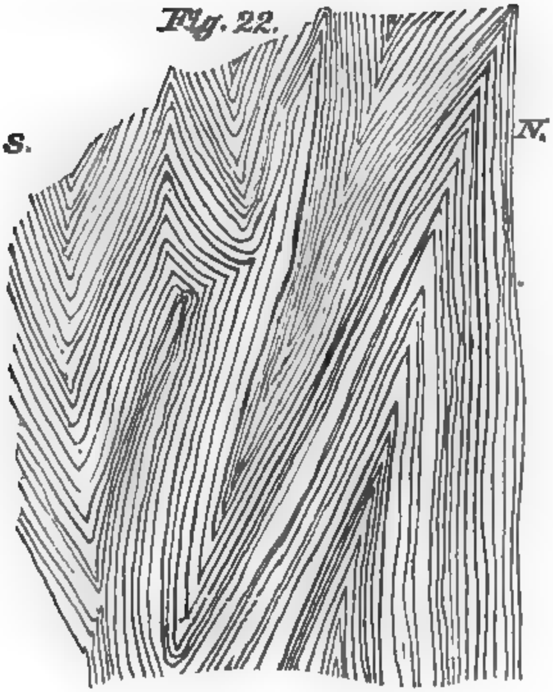


Fig. 22.—*Showing the banding of the jaspilyte in the Stone mine. The surface sketched is perpendicular.*

Farther west, in the Stone mine, a bedding structure passes from the red, "baked" clay, so called, into the jaspilyte, conformable throughout in its bending course. If one is sedimentary the other is. This is not the schistose structure, but the bedding of the clay, forty feet below the surface.

Fig. 23.

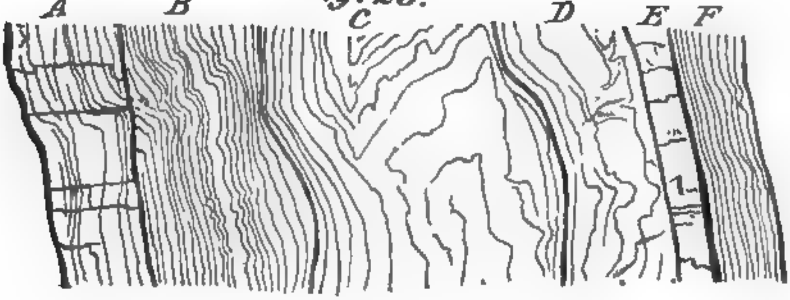


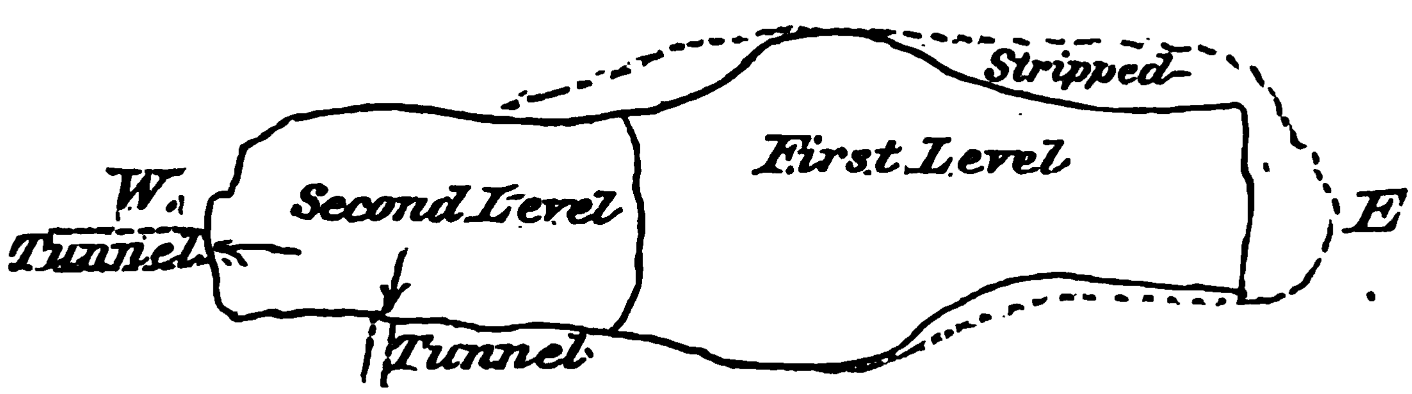
Fig. 23.—*Showing a sedimentary structure continuous conformably from the "baked clay" into the jaspilyte; west end of the Stone mine.*

EXPLANATION OF FIG. 23.

A. Band of rough jasper, eight inches wide.
B. "Baked clay," ten inches.
C. Banded jasper becoming broken, twenty-eight inches.
D. Red schist, eight inches.
E. Hematite, four inches.
F. Schist, six inches.

At the west end of the Stone mine the south wall suddenly makes a bend to the south, the jaspilyte bursting southward. The distance this flexure extends is not shown yet, but it is being uncovered. The north wall does not show this irregularity, at the same place; but a little further west there begins to appear a slow flexure, on the stripped, but unmined, upper surface of the ore, the bands all turning off toward the north. Although the banding in this protrusion is generally broken and confused, it stills runs mainly in an east and west direction — at least it is not parallel with the sides of the mine, as would be expected if the jaspilyte in a molten state flowed into an opening at this place.

Fig. 24.



The Stuntz mine is next east of the Stone mine. Here can be seen a stratified alternation of layers of jaspilyte and schist, similar to that seen in the Stone and Ely mines, there being visible three schist bands from six to ten feet thick, dipping N. or N. N. W. at an angle of about 80 degrees from the horizon. The opened mine runs about east and west and is about two hundred feet long. It shows two levels, from the lower of which a tunnel passes southward for carrying away water and rock, and a drift has been run westward following the ore, with a view to working out above.

Fig. 24.—*Plan of the Stuntz mine.*

The product of the mines of the Minnesota Iron company:

1884	62,124 tons.
1885	225,484 tons.
1886	304,396 tons.

In March, 1887, the following statement was made of the mining equipment of the foregoing mines:

The machinery at the mines embraces two compressors, 20 inches in diameter and 30 inches stroke, operating 30 Ingersoll rock drills in the various openings. Six steam engines drive six hoisting drums, 5 feet in diameter, and also Winze hoists which operate the 11 skips and hoists in the various excavations. Some of the skips are the ordinary iron bucket with wheels and bail, which are automatically dumped at the summit of the skip. Others are platforms on which cars are run at the bottom of the opening and lifted to the surface where they run off on other tracks. Cables are also used to handle cars through a tunnel leading from one of the openings to the dump piles. In one case nine cars are raised from the pit by a boom derrick to tracks at surface level, and in another a counterbalance with pulley sheaves returns empty cars up a long incline which they descend when loaded. Two twenty-light dynamos, driven by an independent engine, furnish light for operating the mine continuously throughout the year. To provide for shipping the ore during the six or seven months when navigation is opened, part of the ore must be mined and stocked in winter. The rigor of the winter in northern Minnesota would seem to preclude active operations in the open pits, but captain Morcom stated that although during the season just closed the thermometer at times indicated thirty and forty degrees below zero, work had not been suspended day or night, the dry, still atmosphere making it possible for labor to be performed with less discomfort than in other regions where a higher winter temperature is accompanied with dampness or penetrating winds.

Quality of the Minnesota hematite ores. The ore is very hard, and must be removed by explosives, dynamite, with about fifty per cent of nitro-glycerine, being chiefly used; but the hard character of the ore has its compensation in furnishing firm pillars for future underground working, and in being richer in metallic iron than the softer ores. Much of the ore is massive or structureless, but sometimes it takes the aspect of specular ore. In physical character the ore closely resembles that taken out of the Champion mine in the Marquette district, and some of the best specimens from the Ashland mine in the Gogebic region.

The chemical analyses, made at the mines by Mr. F. Prince, the assayer of the company, show a high range of metallic iron, and a low percentage of phosphorus. By the

courtesy of Mr. C. Tower, Jr., the managing director of the company, the results of assays made during a period of three months were examined, and an average of 115 analyses showed the following rates. These were on samples taken from the stock-piles in the daily operation of the mines.*

Iron	67.70
Phosphorus	0.06
Silica	1.50

The lowest determination was: Iron, 65.29; phosphorus, 0.067; silica, 3.79. The highest was: Iron, 69.28; phosphorus, 0.0849; silica, 0.68.

The phosphorus in the Vermilion ores varies from 0.021 to 0.110, but in most of the ore as now found it is between 0.04 and 0.07, so that the company can readily maintain a guarantee of 0.06 or less of phosphorus.

The following are complete analyses of the ore taken from the different stock-piles and analyzed by Mr. Prince:

Iron	67.99	68.37	68.32
Phosphorus	0.053	0.057	0.046
Silica	1.35	0.10	1.3
Alumina	undetermined	0.10	0.25
Magnesia	"	0.014	nil.
Sulphur	0.005	0.007	nil.
Loss by ignition	undetermined	0.56	0.06

It is noticeable that the leaner ores are of practically the same composition, except as to silica, as the rich ore, indicating that the inferior ores are those which, lying near the walls or horses of rock, carry free silica. In mining this ore, as above stated, two grades only are made; the great bulk of the ore (fully five-tenths of all that is mined) is sold as "Minnesota Bessemer" and is guaranteed to contain: Iron, 67½ per cent or over; phosphorus, 0.06 or under; while the second grade of ore, "Red Lake," is merely the ore which, being mined close to the walls or "horses" of rock, has more free silica, but is sold to yield iron 62 per cent or over; phosphorus, 0.06 per cent or under. In mining the ore the walls are fairly well defined, so that comparatively small quantities of it are taken off with the ore. The dump piles of refuse would, however, show from 25 to 45 per cent of iron.

To indicate the character of the ore chemical analyses may be quoted, but a more reliable index is in the fact that the Minne-

* John Birkinbine, in *The Iron Age*.

sota Iron company have made one contract for the current year, which is for the delivery of 135,000 gross tons of ore guaranteed not to average below 67½ per cent metallic iron, and with phosphorus not to exceed 0.06. In addition the company will ship over 200,000 tons of ore guaranteed to average at least 67 per cent of iron, with phosphorus 0.06, and 40,000 to 50,000 tons of ore guaranteed to show between 62 and 64 per cent of iron, with phosphorus at 0.6 per cent. There are one or two companies who could deliver large amounts of ore as rich in iron and as low or possibly lower in phosphorus, but there is probably no other iron ore company in the United States that would undertake to meet the above guarantees for 350,000 tons of ore in 1887.

The product of the mines of the Minnesota Iron company, in the third year of its existence, raises it to the second place among the ore producers of the United States.

3. THE MINES EAST OF TOWER ON THE VERMILION RANGE.

In the fall of 1882, H. R. Harvey, an experienced miner and explorer, started eastward from Tower, then consisting of one small log cabin, and cross-sectioned the country until he found some good iron indications in section 13, township 62 north, range 13 west. Winter coming on, a stop was put to his explorations for the year, but the next spring—1883—he renewed his explorations. At the same time Emil Hartman commenced investigating the same field. Both worked from nearly the same point, following up the floats of iron ore and jasper until they worked themselves into the town of 63-12. Mr. Harvey found here in section 27 the outcrop of ore which is known as the Pattison find.

This property is now leased to the Pioneer Iron Mining company. Mr. Hartman, who worked about two miles further east found the outcrop on section 25 in same township, also the outcrops on the Eaton & Merritt claim. In regard to the latter find, Edward Byrne was a few days ahead of Hartman, and is entitled to the honor of the first find on section 30, township 63, range 11.

The first property east of Tower which was brought to development was the north half of the northeast quarter of section 27, town 63, range 12 west. This was done by Mr. Harvey, accompanied by a few men, in the winter of 1885–'86. They worked during the intense cold of a winter in northern Minnesota, with poor and insufficient tools, and opened several test

pits, in order to find the extent of the ore deposit. In the season of 1886. however, none of these could as yet be strictly called mines. No ore had been shipped from them although some good specimens had been taken away for assay. The workings consisted of exploratory pits and trenches. Harvey's pits were six or eight in number sunk to the bed rock through six to ten feet of drift, in some places revealing a jasper-hematite rock in banded striping. At but one point could the dip and strike be seen, owing to the filling of the pits by fallen earth, or by water. At that point the dip was 60 degrees toward the south, 50 degrees east, and the strike was north, 40 degrees east.

One of the most important workings was found in the S.E. ¼ S.E. ¼ of section 28, 63-12, where some trenches had been dug by the owners. They are from two to four feet deep, and in some places they seem to have met with the bed rock but for the most part they are not yet through the surface drift. These surface materials contain not only some first-class hard hematite ore, but also are permeated by and intermixed with much soft hematite, presenting in their finer parts very much the aspect of the "soft ore" deposit of the Gogebic range at Ironwood, indicating the near proximity of considerable deposits of iron ore, though not yet struck in any of these trenches.*

Some drilling and blasting had been done in some jaspilyte ridges in section 30, 63-11, near the north side of the section, but no systematic work had been prosecuted.

Besides these, no working for iron was encountered at any point east of Tower.

In the fall of 1886 a great many explorers visited the region through which the strike of the iron ore was thought to extend, and many additional discoveries were made, beyond what was known at the time of this season's work. At several places land had been taken by "homesteaders" on which, with a scanty prospect of successful farming, were much better prospects of successful mining. These frontier scouts are very persevering and hardy, and they run over the whole country far in advance of any systematic surveying, and of all organized attempts at exploration. They are the *avant coureurs* of settlement. They never settle. They rarely reap adequate financial returns from their discoveries. If they sell out to good advantage the proceeds are generally squandered in dissipation. They are then ready for another similar campaign.

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* Mr. Sheridan submitted some of the hard ore from this location to Mr. Prince for analysis, with the following result: Metallic iron, 68. 24; Phosphorus, .026; Silica, 1.61.

4. GEOLOGICAL DETAILS.

Terms defined. In the notes and descriptions which follow, some common geological terms are frequently employed. Yet, though so common, and perhaps because so common, they are apt to be misunderstood, and differently applied, unless, at the outset, there be a definite understanding and limitation of their intended significance. It is to obviate this difficulty that the following definitions are given.

Bedding structure, is that banding of different colors or shades of color, due to weathering usually, which is brought out on the surface of the sedimentary rocks when they are tilted so as to expose the edges of the bedding. For this term the words sedimentary structure are used in some cases.

Schistose structure may run at any angle with, or coincident with, the bedding structure. It is an imperfect cleavage that is developed in massive rocks, whether sedimentary or eruptive, which on weathering brings to view a finely jagged outline at the broken or eroded ends or edges of rock beds, but not making a real slatiness. Such rock masses appear often quite homogeneous or massive until weathered. It is due to an elongation of the grain and fibre of the interior of the rock in a uniform direction. This structure passes into the next. It is most perfectly developed in old eruptive rocks, while the next is most perfectly exhibited in sedimentary rocks.

Slaty cleavage is the extreme development of the schistose structure in sedimentary rocks such as the graywackes and argillytes. It may cross the sedimentary banding at all angles, or it may coincide in direction with it. It produces cleavable slates, and it hastens the destruction of many rock-bluffs that can not be cleaved into slates, because it opens to the weather innumerable seams, where moisture enters. This structure should not be confounded with a slatiness that is due to the separation into slates of an argillitic, or other rock, along the natural sedimentary planes. This structure is supposed to be produced by great pressure exerted perpendicularly to the cleavage planes.

Foliation is a term used to express the semi-luminated structure of gneiss. It is applicable to crystalline rocks only. It implies a rearrangement of the elements of the rock so as to cause a leaved or sheeted alternation of their beds of different minerals, though each bed generally shades imperceptibly into those on each side

of it. It is supposed to be due to an altered sedimentary structure, and hence is coincident in direction with it.

Strike, whenever mentioned, refers to the direction of trend of the basset edges of outcropping tilted rocks, generally sedimentary, but it is equally applicable to bedded igneous rocks.

Dip is the inclination of the sedimentary bedding planes, expressed in the angle they form with the horizon.

Directions are referred to the true north, a uniform correction of ten degrees having been made, at the time of the observation, for the variation of the magnetic needle to the east of north.

THE NORTH AND SOUTH RIDGES AND THE REGION ABOUT TOWER.

The nucleus of the "south ridge" is jaspilyte, but it has on its flanks other rocks pertaining to the same series, particularly on the south slope, and in the vicinity of Tower. The ridge runs a little south of east, at the west end, averaging about twelve degrees south of east, but the banding of the rock fluctuates considerably. It rises, by aneroid measurement, at the west end 190 feet above Vermilion lake.

The bedding of the jaspilyte, which is smoothed by glaciation, stands nearly vertical, but in some places, separated from each other several hundred feet, it varies either to the north or south a few degrees. The average character of the brown jasper and hematite is expressed by rock number 866.

There are some considerations bearing on the origin of the jaspilyte, which are suggested by a casual examination of appearances on this ridge.

1st. The white quartzyte, appearing amorphous, or chalcedonic, or flinty, on weathering, and especially on those angles where the fires that have prevailed here have had effect on it, becomes granular, and separates into a "scouring sand" of a fine quality, when pounded with a hammer. The brown quartzyte, or some of the so-called jasper layers, act in the same way. These grains of quartz, of nearly uniform size, are very fine, but can be seen under a good hand magnifier.

2d. In some of the beds, both of the white and of the brown sandstone, a distinctly bedded structure, consisting of bands of different shades of color alternating, is plainly visible. It seems as if the collecting of the hematite was most impeded by the siliceous bands, and was carried to its fullest extent in such as

could be entirely replaced. The argillaceous bands, now forming jasper of reddish and brown colors, are intermediate in this graded transformation. The fine banding supposed to be due to sedimentation is visible on several of the samples. No. 867.

3d. The great thickness of the ridge (at least 200 feet), showing the bands standing nearly vertical, if of igneous origin and hence uniformly fluidal at the time it reached the surface, would seem to require that a great fissure was opened and allowed a great discharge of fluid matter, such that the fluidal structure would not be found always standing in the same position and coincident in direction with the sedimentary structure of the country rock. It should be found flowing unconformably over the other rocks.

There are nodules, embraced within the jaspilyte, varying from two to three feet across, accompanying patches of greatly contorted bedding, that seem to show a fusion of this rock. The resulting crystalline rock is represented by No. 866 A. Similar locally fused patches are visible in some places in the graywacke beds, as will be noted at points on the south shore of Vermilion lake. This fusion was due perhaps to pressure and mechanical friction.

This ridge shows a great deal of fracturing, jointing, re-cementing, faulting and twisting of all the visible structure, particularly of the sedimentary structure.

The cementing material in some cases is quartz, of which one vein over a foot in thickness is seen at the west end of the ridge. In other cases the cement is hematite, and this is visible in some of the small fault planes.

At a point about 100 feet above the lake, at the west end of the ridge, but on the southern side, the jaspilyte shows a graduation, across the bedding structure, into other rock like that of the country. (No. 866 B.) This is a gray, fine quartzyte, and is in contact with jasper and hematite, though these are not so characteristically developed as in the ridge proper.

Toward the east the direction of the jaspilyte banding changes, and runs about 12° N. of E. There is a sudden downward jog in the line of the crest of the ridge, but as a continuous ridge of less hight it extends as far as the Lee mine east of Tower. Throughout the rest of its course, however, nearly to Tower, and north from Tower, it exhibits a different geology. The jaspilyte is interrupted, but occurs as isolated masses to a point nearly north from Tower. It is embraced in a green schist, which is the same as that seen at the mines, especially at the Lee mine.

This green schist is a puzzling rock. It acts, in its embracing relations to the jasper rock like an eruptive rock. It surrounds large and small masses of it. It runs with long tongues into it. It winds about and between pieces of it. Some of the embraced pieces of jaspilyte maintain in their bedding, and in their linear extension, an average parallelism with the rock of the main ledge, and to the schistose structure of the schist. Others are brecciated and twisted out of such parallelism. Yet in nearly all its parts, whether in tongues, bands or great masses, this schist keeps its direction and homogeneous composition. But in some places, when crowded between parts of the brecciated jasper and quartzyte, its schistose direction is diverted into a partial conformity with the outer surfaces of those quartzyte masses.

Some of these jasper masses have acquired a pseudo-basaltic structure, from some cause, as if from the effect of this rock, and some of them are blackened as if partially baked, when inclosed entirely within it.

Although these irregular masses, and all the jasper masses involved in this conglomerate, are somewhat ferruginated, they do not anywhere form a genuine iron ore — while some of them are a nearly clean white sandstone. Indeed some of the large pieces are of white sandstone, or arenaceous quartzyte.

Since these are so nearly connected in mineral characters, with the jaspilyte, and can not easily be separated from them except by the less amount of iron present, it would seem that the jaspilyte must have been jaspilyte before the distribution of these fragments, and that therefore this rock (i. e. the rock containing the fragments) can not be of coeval date with the jaspilyte.

Passing southeastwardly from the east end of the high crest of the jaspilyte ridge, already mentioned, the succession of strata passed over may be expressed by the following diagram.

Fig. 25.

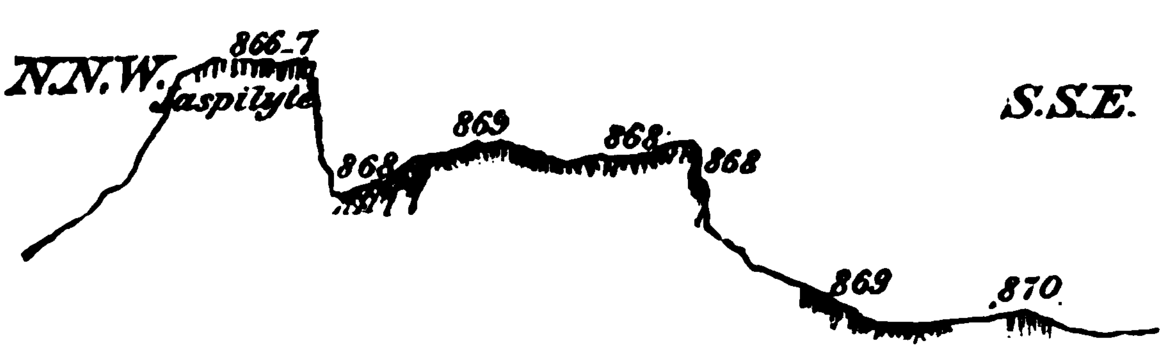


Fig. 25.—*Diagram of the strata extending southeastwardly from the "south" ridge, on N. W. ¼ of the N. E. ¼ Sec.* 32, 61-15.

There is a precipitous descent from the main ridge down to the level of rock No. 868, which is a subcrystalline rock having the appearance of being igneous. This rock occupies an interval of perhaps sixty feet. It is brownish-red, contains quartz (sub-rounded), feldspar, and chlorite. The structure is massive, or basaltiform, and it weathers away faster than the rock on either side of it. Its contact with the other rock can not be found easily.

On the southeast side of this appear many irregular masses of jaspilyte. Indeed there is so much of this rock, though broken and recemented, that it appears to be a recurrence *in situ* of the formation of the main hill. Those parts nearest the rock 868 are a real conglomerate, very coarse. This, however, is much less red and hematitic than in the large ridge, the quartzyte being white and black, in narrow bands, both sometimes showing a red color. The appearance of this conglomerate is that it dips under the rock No. 868, and lies on and in rock No. 869, which is a light greenish, soft schist having a strong and persistent schistosity that runs about east and west. This schist extends to the first hills north of Tower, and occupies a belt at least 80 rods wide, becoming invisible by reason of the drift.

In the line of strike of this schist belt, somewhat toward the east from the east end of the main ridge, is an outcrop of argillyte, which appears to be an incidental phase of the schist, as it seems to fall, in stratigraphic order, into that interval which, further east, is wholly occupied by the foregoing schistose rock. In this argillyte is a perfectly plain sedimentary structure, varying in its dip from 75° N. to perpendicular. The slatiness coincides with the sedimentary structure. The clay slate can be seen, on the north side of the exposure, to graduate into a sericitic schist. The width of the clay-slate belt, paced north and south, is sixty-three feet.

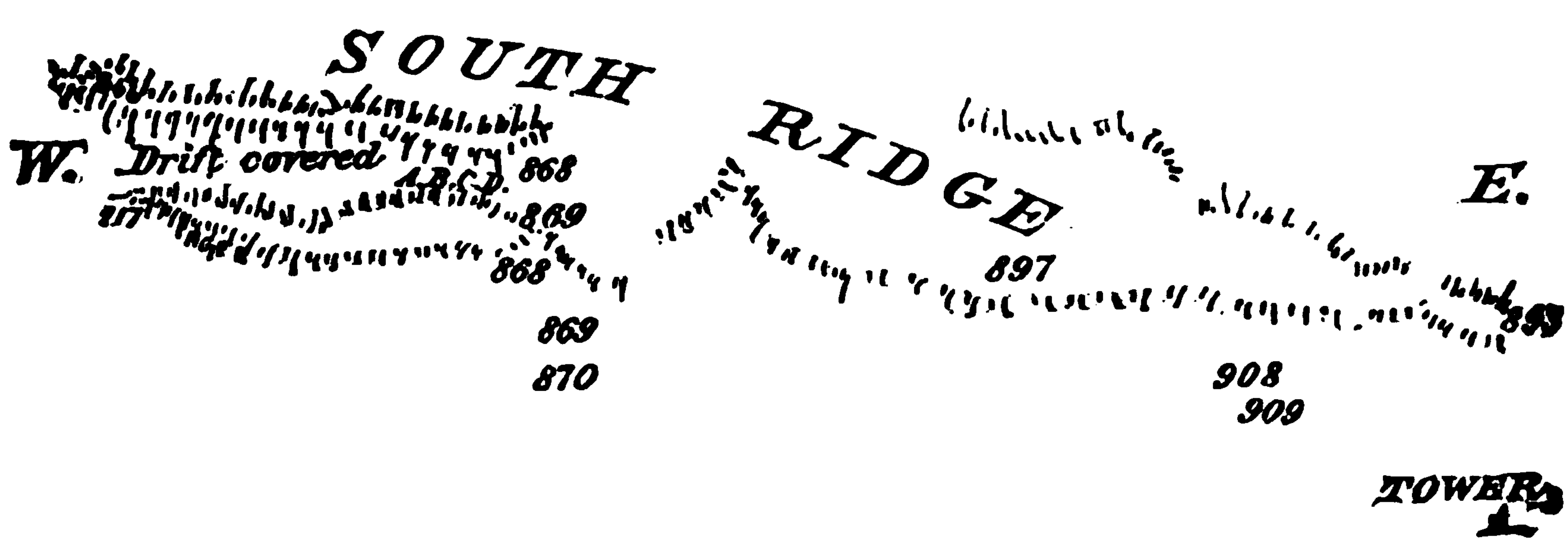
At a point due north from the clay slate there are two belts, or exposures of the rock 868, one being north and the other south of the brecciated and conglomeritic belt of the jaspilyte, but both of them in the subordinate lower ridge. The southern belt makes a precipitous and bold bluff just north of the clay slates, rising forty feet nearly perpendicular.

This rock (868) has in the main everywhere the same general eruptive facies, and it graduates into the green schist that embraces the angular transported masses of jaspilyte seen in the second, or subordinate, ridge. It is much

obscured by the accumulation of coarse drift which everywhere lies on the southerly side of these ridges in considerable abundance. It is cut by lenticular masses of white quartz, and these are so long sometimes as to appear like veins. It is not conspicuously, or regularly basaltic, but has irregular fissures and joints that divide it. It is massive, firm and granular. It is only scantily affected by any gneissic or schistose structure, yet there is apparent, near some of the quartz veins, and along some weathered angles, a schistosity that has the direction of the more finely schistose structure of the rest of the associated rocks. On weathered surfaces it shows a roughly granular aspect, the projections being of feldspar mainly, but sometimes of quartz. Further, there are seen, scantily, impressions of rounded boulder-forms on the weathered surface. and sometimes rounded forms still embraced in the rock. Illustrations of this rock are Nos. 868 to 868 D.

The following figure (26) is a sketch map of the place where the foregoing notes were made, and will give an idea of the geographic positions of the various rocks, and of some others noted below. It embraces the western half of the south ridge:

Fig. 26.



At the extreme west end of the subordinate ridge, west of the locality above described, the rock is bare, and crumbles, causing a sliding lot of debris, consisting of jaspilyte and disintegrating jaspilyte or sandstone (No. 917). The crumbling down is like a sandy bluff, somewhat rusty, but yet a good part of it consists of harder jaspilyte showing the contorted bands peculiar to it.

Further east, on the "south ridge," were made numerous observations on the structure and relations of the various rocks of which it is composed, some of which have been given in discussing the iron ores of Minnesota in a former chapter. Numer-

ous sketches were made here, and several photographs, which will have to be reserved for some future report.

One interesting fact, however, should be mentioned. Not far northwest from Tower is a conglomerate which has the matrix of the jaspery conglomerate in which are embraced the numerous large masses of jaspilyte, but containing also quartzyte, both white and gray, and black siliceous slaty jaspilyte. Among these are also a few pieces of rock that resembles graywacke, or porodyte. The matrix is a coarse, but rather soft greenish schist, apparently passing into porodyte (No. 908). There is a rude structure which has a resemblance to that due to sedimentation, which is about vertical, and strikes 20 degrees south of east. This conglomerate differs from that seen at Stuntz island in having a greater number of jaspilyte boulders, and a smaller number of poroditic porphyroid pebbles.

At a point on the "south ridge" nearly north from Tower a dark slaty quartzyte, or "black slate," stands conspicuously out to view, forming a crag which overlooks the valley toward the south. This slate is bedded by sedimentation and stands about vertical, or dips slightly to the south. It is one of the conditions of the jaspilyte, and is similar to the slates seen in the group further east that have been called the *Animikie slates and quartzytes.* It is the same rock as some of the pieces included in the conglomerate last mentioned. It is situated south from the strike of some of the belts of schist that are supposed to have been unconformably deposited on it, but to the north of others. It is further north than the outcrop of the mixed conglomerate last described, and it may be supposed to have given origin to the rock fragments of this kind seen in that conglomerate. The line of contact between this black slate and the green unconformable schist is seen to show an abrupt transition, and is traceable for some rods to the east of the slaty crag, the green schist being hardened and ferruginated. A little further north is a belt of jasper masses included in the green schist. The situation seems to indicate that the black slate and jaspilyte are parts of the same general formation, and that being firmer than the intervening strata, they project higher above the general surface. When the molten overflow, represented now by the unconformable green chloritic schists, buried them in its progress, it carried along fragments of each a short distance toward the south. This eruptive rock must have been several hundred feet in thickness, since these points are now on some of the elevated

parts of the country, and its disintegration and removal must have involved not only a great mass of rock but a great interval of time. At points further east, however, the apparent continuation of this igneous rock, is more evidently of eruptive origin and exists in greater volume.

At the Breitung mine the involved schist is sometimes nearly white, and has a curving, fine basaltic or columnar structure, much slickensided, the columns being but two or three inches in diameter. In some places it is highly permeated with hematite, and might be called a soft ore. At short distances it varies to a fragile, greenish, more typical form, like that already mentioned at the west end of the south ridge, embracing large detached masses of quartzyte. At the Breitung mine it runs deep alongside the ore, at least as far as the mine has penetrated. It seems as if the distinction between the supposed igneous non-conformable greenish schist, and that which is interbedded with the ore, in successive alternations with it in beds of various thickness, is very difficult in some places to make out. It is yet necessary to ascertain what mineralogical, or what physical characters may be diagnostic of one or the other. Sufficient time has not been afforded for this determination, since these notes were made. Rock sample 884.

South from Tower. Messrs. Jones and Grant made a trip into the country, and Mr. Jones gave the following report:

"July 2, 1886. At a distance of ½ or ¾ mile from Tower we found a range of low, irregular and rocky hills with a trend nearly east and west. After traveling a little further to the south, until we had reached about the highest portion of the ridge, this hight being probably from 40 to 50 feet, we turned eastward, and a little northward. At this point the rock appeared to be a somewhat massive graywacke, showing but little of the quite common schistose structure except on much-weathered surfaces; but as we passed to the eastward the rock seemed to graduate into a very schistose form, having a sericitic aspect. At a point in sec. 5, 61-5, about ⅓ mile from the S. E. corner of the section, northwesterly, we found a cut made by the Duluth & Iron Range railroad through one of these hills. The cut was about thirteen feet deep and a hundred and ten feet long. At the northern end of the cut the rock has a sericitic aspect, of which No. 885 is a specimen, while at the southern end of the cut the rock has more the appearance of a graywacke. The dip we found to be 55 degrees north. Of this, rock 886 is a sample. The strike

is east, 10 degrees north. The rock, as a whole, contains a considerable amount of pyrite and much quartz in irregular veins. For about half a mile, following the ridge toward the east, the same rock appears, with very slight exceptions; and following the railroad toward the south numerous similar outcrops occur for about half a mile. Then comes a considerable amount of drift; and along the track in the S. W. ¼ of the N. E. ¼ of sec. 8, there is a cut 1,200 feet long and 12–14 feet deep, through a bed of gravel and sand; and in the S. E. ¼ of sec. 8 there occurs a cut 18 feet deep and 500 feet long. Of this cut about 12 feet was of rock and 6 feet of drift. This rock was of similar nature to that of the former cut, except being at times more massive, and jointed like a basaltic rock, and at times also more slaty. The dip here we found to be about 45° toward the north, with a variable strike. Specimens 887 and 888 are from this cut.

"The hills for half a mile east, at least, are of similar nature; and numerous outcrops from this point to, say one-third mile south, in N. E. ¼ of sec. 17 are of the same. In fact rocks of no other kind than a schistose, or massive, or a slaty graywacke, approaching at times a sericitic schist, were seen."

Mr. Stacy visited the low hills southeast of Tower, on S. E. ¼ sec. 33, just across the river, and found a succession of ranges running S. S. W., and not in parallelism with the jaspilyte range at the mines, terminating in spur-like projections near the railroad. He examined two of these and found they consisted of graywacke and argillyte, but with a much broken and confused interstratification, the two rocks being in a coarse breccia and sometimes changed to a poroditic rock, like No. 1 (H), which cuts obliquely and directly across the other beds, acting like an igenous rock. In this porodyte, which spreads irregularly, are some pebbles of graywacke, and some other syenite-appearing rocks. At another point he found greenstone dikes cutting the graywacke, varying from 18 inches to two or three feet, and widening out abruptly to eight feet across.

Sample 913 represents the rock seen in the following Fig. 27 as sketched by Mr. Stacy.

Sample 914 represents the rock seen in Fig. 28, sketched by Mr. Stacy.

Sample 915 represents the rock seen in Figs. 29 and 30.

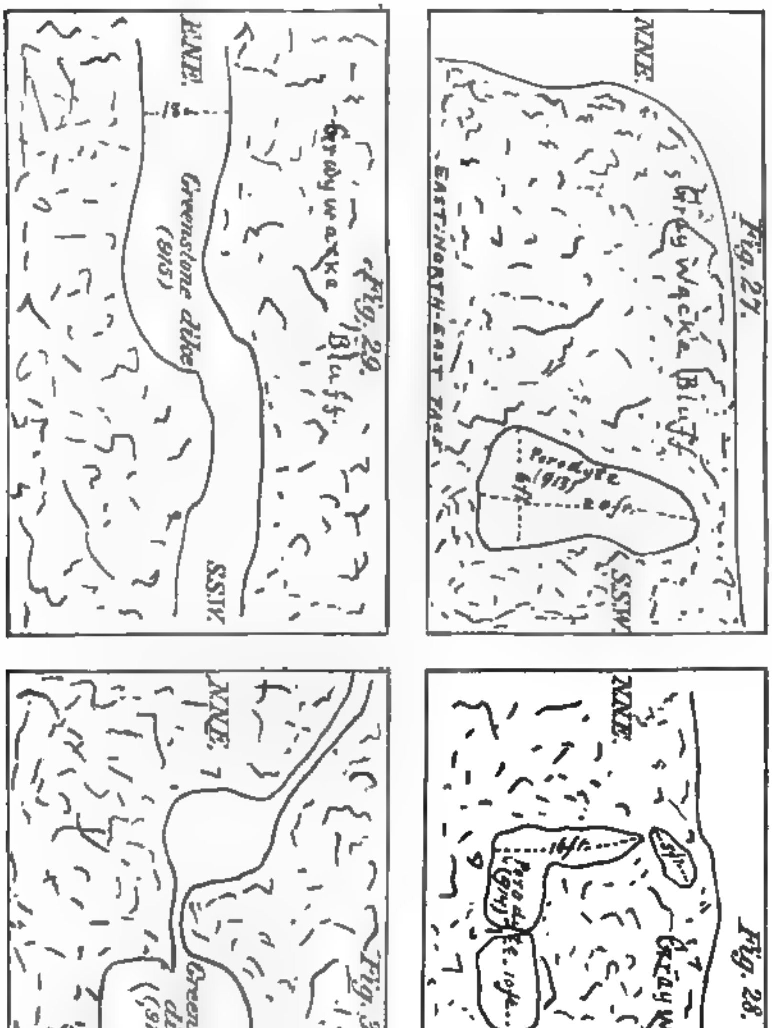
In Fig. 27 the schistose structure runs approximately east and west. The graywacke contains fragments and crumpled and broken beds of argillyte, making a continuous mesh or breccia.

Fig. 27 represents a bluff of graywacke rising about 80 feet high, having the same indistinct schistose structure. It is intersected by irregular and

crumpled meshes of argillyte bedding. The "porodyte" contains occasional graywacke and other pebbles.

The bluff seen in Fig. 29 has the same schistose structure. It consists of graywacke.

Fig. 30 shows the structure near the top of a bluff parallel to and connected with the bluffs seen in Figs. 27 and 28. The greenstone dike winds through a brecciated mesh of graywacke and argillyte. A schistose structure pervades this bluff parallel with that in the other figures.



35 Figs. 27, 28, 29 and 30.

The geology of the "north ridge" is involved in the foregoing chapter relating to the iron ores of Minnesota. But few additional facts need be given. The ridge rises, as measured by aneroid barometer, 240 feet above Vermilion lake. The lake itself is 1,357 feet above average tide level. The ridge rises therefore nearly 1,600 feet above the sea. The principal iron deposit is situated near the central axis of the ridge and forms bare glaciated surfaces on the very highest portion. There is considerable drift on the southern slope, and the rock is hid so that no section continuous from the ore southward can be made out. On the north slope, while the rock is more frequently left uncovered, still there is no continued section. On the north side, at lower levels than the outcrops on the top of the ridge, the same kind of ore is seen in several places, forming conspicuous outcrops, beautifully banded, but running in diverse and unexpected directions, some of the exposed masses being large enough to indicate some value as merchantable ore. There are also large areas of conglomerate on the north slope, similar to that seen on Stuntz island.

At the west end this ridge is deflected northwestward, and, after a lower interval, reappears as an important ridge crossing the north side of sec. 28, and entering sec. 29, rising at this place, however, only about 150 feet above lake Vermilion. It here consists largely of jasper and quartzyte, and is associated with much graywacke and argillyte. The rock here almost uniformly dips from 80 to 85 degrees toward the north, but in some places, especially when it seems to show a connection with the main "north ridge" it exhibits a swinging change in dip through the west to the south, for a space of a few rods. But this is local. Some greenish, soft schist, like that seen in the south ridge north of Tower, and like some seen at the Breitung mine, appears in patches in the jasper and quartzyte, having a concordant structure resembling a dip and strike. But this is the structure that is super-imposed on the unconformable green schists of the region. North of this part of the north ridge are two recurrences of porodyte in alternation with patches of graywacke and one of clay slate or wackinitic slate, running in the same east and west direction. An immense boulder of the Stuntz island conglomerate lies on this part of the ridge, about on the N. E. ¼ of the N. W. ¼ of sec 28. This is 15 feet high and 24 feet long, and about 18 feet wide, lying directly on the edges of the quartzyte, and worthy of being photographed.

Rock No. 918 is from a large boulder near the Breitung mine. Several such were seen about Tower, and must have been somewhere in place not far to the north. The interesting point here is the change taking place in the hornblende crystals, viz., apparently a decay at the centre first, changing the mineral to chlorite (?), while a mere shell of pure hornblende remains. The rock appears to be a coarse quartz dioryte.

THE SHORES OF VERMILION LAKE.

Considerable time was given to a detailed inspection of the shores and islands of Vermilion lake, and some of the notes that follow were made by Mr. H. V. Winchell. His examinations embraced Ely island, the north side of Sucker point and northwesterly to and beyond Shonea island; and he assisted in nearly all other parts of the lake. Mr. Frank Stacy made some independent notes in the extreme western part of the lake, and in the northeastern. Some places were examined two or three times and by two or three different observers, often in company, in order that there might be a consistent and uniform understanding by all members of the survey, of the phenomena described by them, and the terms employed.

The description will begin with the place where the central camp of the survey was located, and will be continued toward the west and northwest round the lake to the starting point, though the order of examination was not in this direction, nor in any uniform course. The specimens were numbered serially as collected, and follow the order of examination chronologically. Those collected by H. V. Winchell are numbered independently, and are distinguished from other series by having the letter H in parenthetical lines following the arabic numerals.

Hoodoo point. This point is in the southern half of sec. 30, 62-15. The main camp was on the south shore, on the S. E. ¼ of sec. 30. The land is low, and was originally swampy, but the trees have been burnt off, and the surface is found to recede gently from the lake shore eastward, leaving a part which is dry throughout the year, facing the lake toward the west and southwest. It has a good clay soil and subsoil, but it is surrounded on the east by a swamp which is nearly impassable, separating it from the rocky ridge, about a mile distant, which rises between it and Tower. The clay, which rises about five feet above the lake at time of average water, is fine, gray and stoneless,

evidently deposited by the lake at some earlier time when it stood permanently higher than now. Owing to the prevalence of a gray till along the southwest side of Vermilion lake, governing the general contour of the land and the location of the present lake shore, it is probable that this clay is closely allied to that, though not stony, and derived from the gentle assorting action of the lake on the till at some stage in its history. Tests have not yet been made to ascertain whether this till, and hence this fine clay is of the western alkaline class, suitable for the manufacture of light colored brick, or is derived from the disruption and comminution of the crystalline rocks of the region, and thus suitable to make red brick, but geographic considerations rather favor the former. This clay must underlie all the southwestern shores of Vermilion lake where they are no higher than this, unless the stony till has preoccupied them. A sample is obtained for comparison with other similar clays in the state.

The bay between Hoodoo point and Hoodoo river is lined by a sandy beach, but near the base of the point is a low outcrop of graywacke and poroditic graywacke. There is another similar outcrop, nearly covered by boulders, at the picnic point at the mouth of East Two rivers.*

Beef bay. The point at the east side of sec. 36, 62-16, is one of boulders, but a little further west is a bold exposure of firm, fine-grained schistose schist, evidently siliceous but without evident free quartz, apparently a changed felsyte, or a porodyte in which the schistosity has been developed. The fibre runs 10° S. of W. and is perpendicular.

Boulders and drift materials hide the rock along the shore to the centre of the N. E. ¼ of sec. 3, 61-16, where a small point that projects northward exposes a low glaciated surface of hard schistose graywacke which is represented by No. 864. About a square rod of rock surface is visible. The schistose structure runs E. and W., and is not distinctly separable from the bedding structure. The rock is purplish-black.

The rock here is brecciated, and recemented by a poroditic rock (finely porphyritic) resembling No. 2 (H), but of a darker color, approaching the color of the rock of the breccia. In the midst of this cementing rock are pebbles, or fragments, of slate resembling the breccia, but the pebbles are elongated in the

*The aboriginal name translated "East Two rivers" should be abolished. It might be called Hoodoo river, for the same reason that Hoodoo is given to the point so designated, meaning the river that dupes or makes a fool of the canoe-man not perfectly familiar with the country.

direction of the schistose structure, and are porphyritic faintly with white crystals of a feldspar like those in the cementing rock.

On the S. E. ¼ of the N. E. ¼ of sec. 3, 61-16, about forty-five feet above the lake, at the site of the old town of Winston, the cementing rock last mentioned rises in a bare smooth dome. It is here massive, weathering whitish, showing no visible sedimentary structure, nor evident schistose structure—though there is in some places an apparent short, coarse striation that runs about E. and W. It is cut by numerous joints, some of them such that if the rock were to be disintegrated it is likely that a so-called basaltic structure would become apparent, similar to that in the trap rock at Taylor's Falls. There is no uniformity in the direction of any system of this jointage, but, taken altogether, there is a prevailing distinctness in those lines that vary from N. 10° E. to N. 10° W. This rock contains abundance of free quartz in small grains, but not so large as in No. 1 (H). Some of the feldspar grains are angular, but very fine. This rock might be styled graywacke, but there is no trace of any original bedding, which is the usual accompaniment of graywacke. The color within is greenish-gray. There is a close alliance in all features that are outwardly distinguishable, between this rock and the felsitic conglomerate seen in Stuntz island.

At the mouth of Pike river, which enters at the extremity of Jones bay, in the western part of sec. 3, T. 61-16, on the right bank, at twenty feet above the water, the outcropping rock shows a sedimentary structure running about E. and W., coincident with an imperfect schistose structure, the dip being S. 80° from the horizon. This is nearly a typical graywacke, but it embraces beds that are more massive, with fine disseminated quartz, and resembling some of the felsytes. This dip does not prevail far but is replaced by structures running in various directions, and separated by faults. In one place a coarse granitoid rock, like No. 1 (H), constituting a bald, prominent elevation, occurs suddenly as if eruptive. The relations are obscured by the prevalent drift.

At the falls of Pike river the rock shows plainly, and nearly everywhere, a bedded sedimentary structure, crossed by faults that cause jogs of a few inches, or even a foot. The following sketch was made here in 1878:

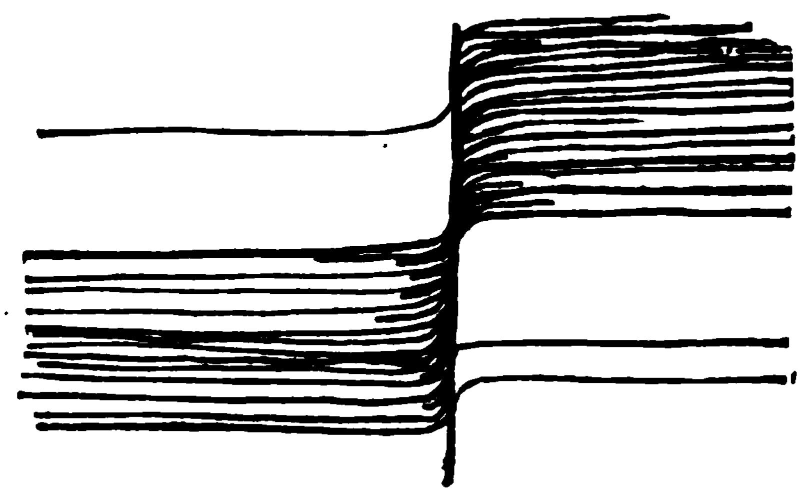


Fig. 31.—*Showing a fault in the graywacke at the falls of Pike river.*

What is significant and important here is the interstratification of rock much like the massive graywacke seen at the old site at Winston, containing fine grains of quartz, in layers repeated many times, from one inch to four inches in thickness, with the darker, slaty graywacke. Some of these bluish-gray layers, which weather lighter colored than any of the rest, are evidently quartzytes with but little feldspathic matter, but some are quartz-felsytes or porodytes, and are like some of the beds that show in some places, many evidences of being of igneous origin. This bedding runs 10° N. of E. and dips 80° south, 10° E. There are some veins and segregations of white quartz, some of the latter coincident with the bedding.

The head of the bay is marshy, but there are low hills at a short distance from the shore.

On the point near the S. W. ¼ of sec. 34, 62-16, is a gray quartzyte, represented by rock 865. This shows a very evident sedimentary banding. It has a slight exposure on the north side of the point, and while standing nearly vertical, like the graywacke near the mouth of Pike river, yet dips N. 85°, (25° E.) from the horizon. Toward the north it varies to a graywacke slate with concordant stratification, and toward the south it varies to a porodyte, the latter showing the same evident sedimentary structure.

The next point toward the east, in sec. 34, 62-16, nearly north from the centre of the E. and W. line, is of porodyte, or quartzose graywacke, which has much feldspathic material. This is schistose in a direction coincident with a doubtful sedimentary structure, running E. 20° N. The dip is S. 85°—90°, 20° E.

There is considerable coarsely schistose rock seen at some of the points in the S. E. ¼ of sec. 34, 62-16. This weathers light colored, and seems to be of the nature of the felsitic rock of

Stuntz island, although such rock has been and will be in future descriptions provisionally included under the term sericitic schist.

The southwest end of the large island in sec. 35, 62-16, shows a schistose poroditic rock rising about 20 feet, rudely bedded in coincidence with the schistose direction, dipping S. 20° E. about 85° from the horizon. This bedding is perhaps not due to sedimentation, but is a variation in the composition which might be called more correctly foliation. It is crossed by jointage planes running in nearly all directions. This seems to be the continuation of the similar rock seen at the old town site of Winston.

The coast line along the north side of Beef bay is composed of drift materials, which continue easterly to the point near Whisky island, in the N. E. ¼ sec. 36, 62-16. This point contains graywacke rock at the extremity, but Whisky island consists of sericitic schist, on the north and west sides, and the rock of this island is hid otherwise by drift.

Sucker point. The coast line again consists of drift along the south side of Sucker point through sec. 25, 62-16, and sec. 30, 62-15; but round the shores of Sucker point in sec. 19, the underlying rock frequently appears, consisting of graywacke or felsitic rock that is intimately associated with graywacke.

On the south side, in the N. W. ¼ of the N. W. ¼ of sec. 30, 62-15, no rock except boulders can be seen. In the N. E. ¼ of the N. W. ¼ of the same section, the point rises up to 45 feet high, and a conglomeritic felsyte crops out, similar to that seen on Ely island. It is quite hard, being but little weathered, and is full of pebbles, some being of graywacke, and some like the ground-mass of the rock itself. The schistose structure is E. and W., with no ascertainable dip. On the S. W. ¼ of the S.E. ¼ of sec. 19 the schistose structure runs 10° S. of E. A small island here is made of this rock. It is about 20 feet across and four feet high. On the north side the rock appears to be what could be styled felsyte, but toward the south it seems to grow more and more fine-grained and to turn into graywacke within twenty feet. Both have here the same schistose structure, and both have a basaltic structure. This is Kego or Fish island.

On the point, northeast of the island (S.W. ¼ of the S.E. ¼ sec. 19), the two kinds of rock grade into each other even more than they do on the island. In the S. E. ¼ of the S. E. ¼ of sec. 19, on the point, the felsyte and graywacke come together again. There is an indistinct line between them, on the surface, not discern-

ible when broken or on a fresh surface. The felsyte contains pebbles of the other, and small cubes of pyrites. The graywacke dips south (?) and contains large cubes of pyrites. A common schistose structure pervades both. A little further on, the dip is plainly toward the north.

The point in the north half of the S. E. ¼ of sec. 19 is low, and almost covered with boulders, specially round the north side, some of them being at least fifteen feet in diameter.

On the north side of the point, in the S. W. ¼ of sec. 19, the rock resembles felsyte, as here designated, though it has a greenish color, frequently weathering nearly white. It here seems to have a bedding running 30° S. of E., while the schistose structure is E. and W. This is the first place seen in which a bedded structure appears in a rock that resembles felsyte more than graywacke. In the bay S. W. ¼ of sec. 19, the felsyte turns green, and resembles No. 3 (H).

On the small island, north of the point, in the S. E. ¼ of sec. 23, 62-16, the rock is a sericitic schist or dioryte. It is greenish and resembles No. 2 (H.), but is finer grained, with an east and west schistose structure, merging into the graywacke on the south. The rock shows various colors from green to brown or red, and contains some quartz and pyrites. The line of separation of these two rocks is hard to find. The bedding of the graywacke is somewhat disturbed and broken near the place where the two come together, but has a general directon 35° S. of E. Part of the supposed dioryte seems to have a bedding parallel to that of the graywacke. There are veins of quartz, an inch in thickness, and larger masses of jaspery rock, more or less changed, contained in the dioryte.

Near the centre of sec. 26, 62-16, is a low exposure of black slate containing veins of quartz. The structure in some places is somewhat distorted, but in others very smooth and straight. The bedding and schistose structure run S. 6° E.

In the S. W. ¼ of the N. W. ¼ sec. 26, is a large mass of greenish black slate or slaty schist, with a schistosity running 10° S. of W., and a bedding 14° S. of E., the former having numerous siliceous veins, and some veins of pure quartz, running parallel with it. At this place, twenty years ago, a shaft was put in, and considerable work was done, the depth of 35 feet having been reached, wholly in the dark slate. Several log houses were put up, but the place has all been abandoned. The dip of this rock is slightly toward the north. On the surface, near the lake, the

rock does not appear so slaty, but is more like a fine-grained graywacke and has very distinct bedding. The north side of each stratum has the schistose structure obscure, but the sedimentation very plain. The strata vary from six inches to a foot or more in thickness. The shore line thence through secs. 23, 22 and 16 consists of drift, without rock exposure, rising from ten to forty feet at a short distance inland.

Birch point. Near the east line of sec. 16, 62-16, is a small exposure of slate on the south shore. The whole of this point, in sec. 16, is probably closely underlain by rock, but it is hid by drift.

The island which is crossed by the line between secs. 15 and 16, 62-16, is mostly composed of a gray, poroditic or sericitic schist. It is hard, tough, compact and almost massive. It has pyrites, more or less disintegrated, all through it, giving part of it a greenish look. The schistose structure is obscure, but seems to trend E. and W. The island rises about twenty-five feet. Rock No. 4 (H).

This point, further east, rises from 30 to 50 feet above the lake, but consists of drift. Only boulders are seen on the beach, throughout secs. 15, 11, and to the S. W. ¼ of sec. 10. The island off the point, near the centre of sec. 11, has an underlying rock-structure of sericitic schist.

The island north of Birch point, in the S. W. ¼ of sec 10, shows an outcrop of sericitic slate running E. and W. with a slight dip to the north. West of the slate, on the south side of the island, the rock is more schistose, and less slaty.

On the N. W. ¼ of sec. 16, 62-16, on the north side of Birch point, is a low exposure of greenish sericitic slate. The bedding and schistose structure coincide, and run E. and W. The dip is apparently to the north, though not so plainly, nor so much, as on the small islands in the S. E. ¼ of sec. 9, 62-16. There are numerous small veins of quartz in the rock, running parallel with the schistose structure. The rock is not a good slate, but the bedding is so straight and regular that it splits into slaty slabs and fragments in some places. In others it is simply a schist.

One of the small islands in S. E. ¼ of sec. 9 is composed of a somewhat slaty greenish sericitic schist, with its structure running E. and W. It is full of pyrites cubes, up to ¾ inch in diameter. The dip is slightly to the north. The island rises eight or ten feet out of the water.

At the corner post of secs. 7, 8, 17 and 18, 63-16, is found a green schist (5 H), even-grained and moderately firm. It rises but two or three feet above the water, and is soon concealed by drift. The dip is not apparent. There is no perceptible bedding, and the schistose structure seems to run E. and W., although it is not very marked. This rock has a basaltic jointage suggestive of an eruptive origin. On the north side of the bay, in the S. E. ¼ of sec. 7, 62-16, is a massive, syenite-looking rock, grayish-red to greenish in color (6 H), rising about ten feet above the water in rough, bold crags or hillocks. It has no evidence of metamorphism nor of sedimentation. There are seen a few masses of chlorite-like material, but the most of the rock is homogeneous. apparently containing orthoclase, quartz and hornblende or chlorite, and a little pyrite. The rock has the general appearance of having an eruptive origin.

Black Duck point. Further east, in the S. W. ¼ of sec. 8, 62-16, there is a low exposure of graywacke, and east of this, about the middle of the section, the syenitic rock again crops out. The hills are covered with drift, and heavily wooded, so it is not possible to see where this rock and the graywacke come in contact.

At the S. E. ¼ sec. 8, 62-16, is a siliceous schist which seems well adapted for whetstones. It is fine-grained and evenly sheeted. It runs E. and W., rising but ten feet above the water. It contains small particles of a dark greenish mineral that become rusty and red near the surface. There is a slight dip to the north. (7 H.)

A conglomeritic rock outcrops at the same place; this is rather fine-pebbly, with feldspar and quartz pebbles or crystals. The color varies from reddish to greenish, the pebbly structure being more evident near the surface than further in. There seems to be an east and west schistose structure, the matrix being apparently a sericitic schist. The connection between this and the last can not be discovered, as it is covered by drift and the water of the lake.

Some mining has been done on the N. W. ¼ of sec. 9, 62-16, in rock that resembles 7 H. It here appears to be eruptive, and in dikes through the graywacke. On the south side of what may be a dike the dip is toward the south, and on the north side it apparently dips north. There are some small veins of quartz.

These have been followed, in the mining, thirty feet or more. East of here the hill appears to be composed chiefly of a green rock, like trap. (9 H). It has come up in the sericitic schist,

and thrown it over till it lies almost horizontal, with a slight dip to the north. It has the general form of a dike running across the sericitic schist diagonally from S. E. to N. W., but this is not certainly the structure. The hill in which it is found rises 90 feet above the lake, and is heavily wooded. Some syenitic rock is also found here.

On the point, S. W. ¼ of the N. W. ¼ of sec. 10, rock No. 9 (H), has a large exposure. Here it seems to almost have a structure in the direction of that of the graywacke. It is low, and has a basaltic jointage. On the next point bedded graywacke is seen running E. and W. Here it is evident that the doleryte No. 9 (H), runs in the same direction as the regular graywacke, and near their junction contains pieces of it. It looks more than ever as if No. 9 (H) were a changed condition of the graywacke, and not eruptive.

Graywacke forms the small rounded island in the S. E. ¼ of the N. W. ¼ of sec. 10. In this are small dikes running nearly, but not quite, parallel with the schistose structure; but about 10° to 18° N. of E., while the graywacke runs E. and W. The rock in these small dikes (two inches thick) resembles No. 9 (H).

The large island off the end of Black Duck point, crossed by the line between secs. 3 and 10, rises from thirty to fifty feet above the lake and consists of a rock sub-structure of graywacke varying to a greenish schist, dipping to the north, considerably obscured by drift.

In the S. W. ¼ of sec. 33, 63-16, are outcrops of rock ten or more feet above the water, that are greenish, and have the massive structure and basaltic jointage of eruptive rock. They show no sedimentary structure, and but feebly a coarse schistose cleavage. There is no apparent dip.

On the west side of Black Duck point, S. E. ¼ of sec. 5, 62-16, are seen dikes of rock resembling No. 2 (H), running through the graywacke or sericitic schist, in a direction that varies from 10° to 20° north of east. This rock stands unconformably by the side of, and in, the schist, and incloses many large masses of the same. The rock of these dikes is quite homogeneous, and does not contain, apparently, any pebbles, such as seen in No. 2 (H). The dikes vary from 3 feet to 6 feet in width. Rock No. 10 (H).

No. 11 (H) is from a dike running through the graywacke in the S. E. ¼, S. E. ¼ sec. 5, 62-16. It is a tough, grayish green rock containing considerable hornblende. It is also pyritiferous,

and has veins of quartz running through it, and scattered nodules of syenitic rock, but no free quartz in the rock itself. It contains black mica and exhibits a coarse schistose structure. The dike runs parallel with the bedding of the graywacke, while the schistose structure of the graywacke is 20° N. of E. In secs. 5, on both sides of the bay, graywacke is the underlying rock and is considerably disturbed by dikes, sometimes appearing twisted almost as badly as the bands in the jasper in T. 62-15.

Argillaceous schist which approaches slate in hardness and firmness of grain, appears in the S. E. ¼ of sec. 6, 62-16. It forms a knoll, and runs 50° E. of N., dipping S. Coincident with the schistose structure are numerous small quartz veins. A little further west the rock is about the same, but seems to be mixed with lumps of harder more siliceous rock of a pinkish color and fine texture. In the N. E. ¼, S. E. ¼ sec. 6, 62 16, this argillitic rock runs 10° S. of E. It is quite hard, and only a little of it is exposed. There is a considerable amount of the harder pink rock in it.

In the S. W. ¼ of sec. 6, 62-16, is seen a heavy fine-grained schist. Running through it is seen a considerable amount of some fine-grained feldspar, resembling orthoclase in color. There also appears to be some mica in some portions of the schist, and pyrite in nearly all. In one place a bed or stratum was seen that apparently contained hematite. There is an evident bedding, or foliation, dipping a little to the west of south. In the southern part of sec. 7, T. 62-16, are seen hills that rise about 100 feet above the lake.

In the S. W. ¼ of sec. 6, near the town line, is an exposure of greenish schist, approaching graywacke, which has been filled with crystals of pyrite, but they have weathered out and the rock has somewhat the appearance of an amygdaloid. Near the town-line, N. W. ¼ sec. 7, 62-16, is an outcrop of a heavy, massive, greenish black dioryte, which probably is in a dike, though the boundaries of it can not be ascertained. It contains mica, hornblende (passing to chlorite) and feldspar. It extends for 100 feet or more. No. 15 (H).

On the south side of this dike, or at least just south of it, is a large dike, or bed, of porphyritic feldspar rock No. 16 (H). This rises 20 feet in a bold knob. The crystals of triclinic (?) feldspar, half an inch long, stand out thickly all over the weathered surface. There is some quartz in the rock, and there appears also to be hornblende. The connection between this and the rock

on either side is covered. There is a quartz vein a foot or more thick running through it 50° E. of N. These two rocks, 15 (H) and 16 (H), alternate several times along here, but are not seen in contact so as to disclose their relations.

Birch bay. In the S. E. ¼ of sec. 1, 62-17, the outcropping rock is a greenish sericitic slate containing much pyrites. This rises but a foot or two above the water, and has a schistose structure running 10° N. of E. The dip is toward the south. On a small point a little west of the last, the rock is still a greenish sericitic slate. The bedding is wavy, and runs in a general E. and W. direction, while the schistose structure crosses it in a direction 10° N. of E. There is a small fault across the bedding which is of later date than a short vein of quartz, for it runs through the quartz and has carried part of it six inches toward the northeast from the rest of it.

The small island east of the point in the S. E. ¼ of sec 1, 62-17, is a very nicely exposed knoll of greenish sericitic schist. It has a very plain bedding structure running 20° N. of E. and a schistose structure not so plain running (40°?) E. of N. It is slaty in some places, but generally is too soft to be called slate. The bedding lines are bent or curved somewhat in all directions. There are numerous short veins of quartz, up to a foot or more in thickness, running principally in the direction of the bedding.

On the point in the S. W. ¼ of the S. E. ¼ sec. 1, 62-17, there is a greenish siliceous (?) schist (17 H) that has but faint bedding, nearly vertical, and basaltic jointage. It rises immediately out of the lake, ten feet or more, and is considerably broken up. This rock is about the same as 14 (H).

About the N. E. ¼ of the N. E. ¼ of sec. 12, No. 16 (H) appears again, in the same bold, high fashion as on the other side of the point. Here it seems to come up through sericitic schist on its south side, and probably the same on its northern side. A little further southwest is a large high bluff of rock considerably like 16 (H), and also like 12 A (H). It extends along the shore of the lake for two hundred feet or more, rising 20 feet above the water.

South of this is rock like No. 14 (H), only a little redder. It has basaltic jointage and a kind of bedding. It dips a little to the south, and extends 50—100 feet; still further south rock like Nos. 12 A (H) and 16 (H) returns for forty or fifty feet.

South of this is a clay slate with schistose structure running a

little E. of N. Then comes a harder, firmer slate-like rock, except that it lacks the even bedding of slate. This rock grades into sericitic schist, which continues, more or less firm, until it passes into a sort of semi-crystalline rock which has a coarse schistose structure running about 40° E. of N. The hight of the hill, here, has diminished to four or five feet.

On the small island on the S. E. ¼ of the N. E. ¼ of sec. 11, 62-17, there is a small point about five feet above the water, composed of hard greenish rock, with no plain bedding. It has a schistose structure running 40° S. of E. There is a lining, which may be due to a sedimentary bedding, running in about the same direction. Rock 18 (H).

On the south side of the island in the N. E. ¼ of sec. 11, 62-17, is a striped red and green schist, standing nearly vertical. The bedding is much disturbed, but runs about 30° S. of E. Dip is N. rather than S. On the N. W. end of the same island there is a low outcrop of dark green, hard, fine-grained, hydro-mica schist. It has bedding running 10° S. of E. and a schistose structure running 30° N. of E. There are many small veins of quartz running in the direction of the bedding. Boulders are very numerous at the west end of the island, and cover the rock almost wholly.

The coast line then is one of drift and boulders as far as the N. ½ of the S. W. ¼ of sec. 3, 62-17, when hills of mica-schist rise, near the coast, to the hight of ninety to a hundred feet. The first rock seen, in coming up along the shore from sec. 10, is the greenish sericitic schist so abundant east of here in this bay. This has a schistose structure running 60° E. of N. Out of this rises a hard, tough, pinkish-green, crystalline rock, whether syenite or dioryte is hard to say. It is chiefly composed of feldspar and hornblende, with a greenish mineral besides, and some pyrite. It is hard and massive, and it makes a great ridge. It is No. 19 (H). It is not more than 20 or 30 feet wide, and on the east and north mica-schist appears. Along the coast these two rocks alternate, the mica-schist occupying lower levels than the syenite; but the schist is also very hard, and almost massive, with a schistosity, or foliation, running 20° N. of E. The high hills in the north half of sec. 3, along the shore, run in the direction of the trend of these rocks, and are caused by them, the summits of the principal alternating ridges being composed of rock No. 19 (H). The alternating rocks occur in belts or beds that vary in thickness from ten or twelve feet to forty or fifty feet.

In the N. E. ¼ of sec. 3, 62-17, can be seen a dike of red syenite, about six inches wide, running through the rock No. 19 (H), about east and west. It is faulted off in one place, about eight inches. This is represented by 19 A (H).

In the N. E. ¼ of the N. E. ¼, sec. 3, is a dike of pinkish syenite running through the schist 50° S. of E., while the schistose structure is 30° N. of E. This dike is much like 19 A (H), but is a little coarser, and not quite so pink.

On the W. side of the island, in the N. E. ¼ of the N. W. ¼ of sec. 2, 62-17, is a large dike of No. 19 (H), running about 30° north of east. It contains some few narrow crooked veins, or beds, of mica-schist. There are also in it dikes of the light white to pink syenite which go in all directions through the greenish dike.

On the south side of the small island in the centre of sec. 2, is a bed or dike of pink rock, almost wholly of feldspar, coming through a hydro-mica-schist. It is not very hard but is particularly decomposed into angular pieces of various sizes. It is a schist, and grades into a hydro-mica-schist, in almost imperceptible degrees. This is rock No. 20 (H).

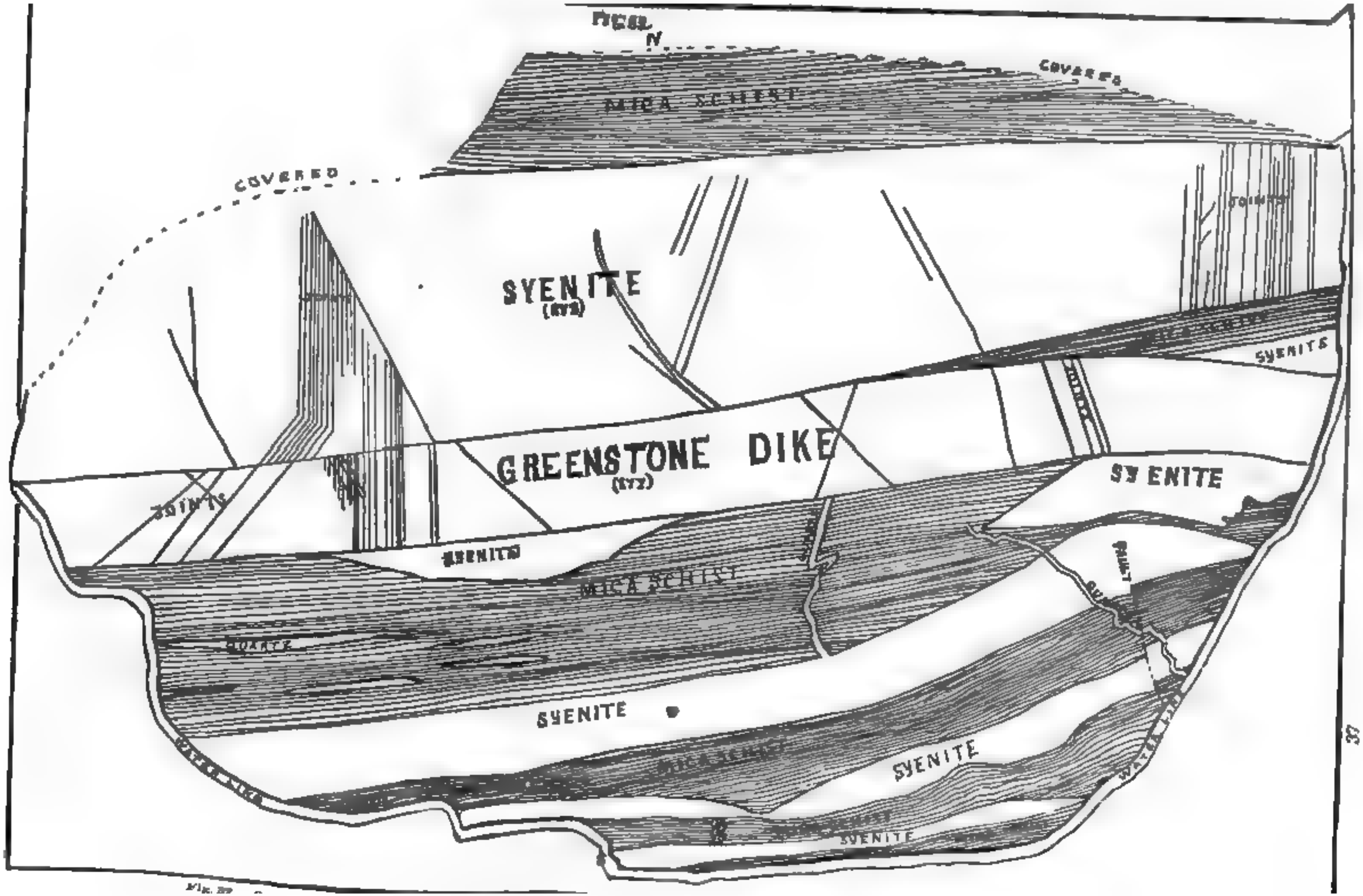
On the small island 25 feet across, in the S. E. ¼ of sec. 35, 63-17, is a felsitic conglomerate, or porodyte. It has a schistose structure running E. and W. The island rises less than two feet out of the water, and is composed entirely of this rock. It has a matrix of apparently sericitic schist, and there are in it pebbles of quartz of all sizes and shapes up to three inches in diameter. The structure is bent and doubled considerably, and there is no certainty of any bedding structure.

Birch river and Avis island. The little islands that lie south of Avis island, forming the canoe and the steamboat channels from the upper lake, are composed of mica-schist, variously cut by and mingled with dikes of two other rocks.

On a little island near the centre of sec. 36, 63-17, in the north part of the "canoe passage," the rock is mica schist. There are visible on it, however, no real dikes that cross the bedding, though they are visible on the larger island next west. The surface of the rock on this little island is ridged by unequal erosion and decay in weathering. The ridges are prevailingly in several pronounced directions. First, are those that coincide with the bedding structure. These consist of variations in the rock itself and of quartz. The quartz is chemically deposited and did not exist at first as part of the bedded rock. It is vit-

reously crystalline, and about white. The others are micaceous quartzyte, sometimes being dark like the mica-schist and sometimes gray, or nearly white quartzyte. These both show, on their flat surfaces, wherever the mica-schist has been removed by weathering, a striated appearance, resembling glacial marking, that runs at an angle with the horizon, of about 40°, descending toward the west. This striation, however, is due to the internal variations in the hard rock, and becomes visible only on the removal of the softer rock. The second kind of ridges crosses the first at about a right angle; and they are so frequent and abundant as almost to produce a schistosity in that direction. They dip toward the N. E. at an angle of about 45°. Their cause is apparent. On the weathered, upper edge of each one of them, or many of them, can be seen an open fine fissure splitting the ridge longitudinally into two parts, the hardened schist being hardest just at the plane of contact of the two halves, so that the fissure really splits the edge of the ridge. The bedding, and a kind of foliation or gneissic structure coincident with the bedding, is not disturbed by these ridges, but the mica scales, etc., are elongated E. and W. instead of N. and S. This hardening of the schist on either side of these minute fissures is due, apparently, to the action of gases and chemical secretions on the adjacent rock walls. Such would gather in the fissures, and in all passage-ways, more readily than elsewhere, whenever upheaval, or any disturbance, should produce the openings. The third kind of ridges passes irregularly and confusedly across the surface of the mica-schist, but they consist, like the last, of hardened belts in the mica schist. They are less conspicuous than either of the last, and less frequent; but they are sometimes broader — ½ inch to 3 inches. The first and second kinds vary from the faintest linear elevation to ½ inch or 1 inch across.

The plat sketch, represented by fig. 32, was taken from the glaciated rock-surface in a little bay on the northeast end of Menan island, not far from the centre of sec. 36, 63-17. The shaded portion, representing mica-schist, the main rock of the country, is shown to have been broken first by some force and cemented by some very quartzose syenite. Subsequently these were both fractured and the opening was filled by the greenstone dike. Neither the syenite nor the greenstone is conformable with the strike of the mica schist, which is 35° E. of N., although they seem to run, in general, in the same direction. The greenstone dike is amygdaloidal, but the amygdules appear now to


MICA SCHIST
COVERED
COVERED
JOINTS
SYENITE
(872)
GREENSTONE DIKE
(872)
JOINTS
SYENITE
SYENITE
SYENITE
MICA SCHIST
QUARTZ
FAULT
SYENITE
MICA SCHIST
SYENITE
SYENITE
WATER LINE
WATER LINE

be wholly of fibrous hornblende. This structure is not visible throughout it, but is so in nearly all parts of it. The rock consists mainly of hornblende and a triclinic feldspar, making a dioryte. Rock samples 877 and 878.

On the northern slopes of this island, northwest of the point sketched, are other greenstone dikes, and irregular areas of syenite, one of the dikes of greenstone being about eighty feet wide, running in the same direction. The island rises 10 to 15 feet.

At numerous places on and about Avis island, rock like No. 878 (syenite) is seen crossing the mica-schist in diverse directions in the manner of dikes, some of them being nearly horizontal. In some small areas and knobs, nothing can be seen but the syenite, in other places small areas of mica-schist appear, more or less inclosed by syenite. The dip is uniformly preserved toward the south, 25° — 35° east. On the south side of the island, hills of this kind of rock rise about fifty feet above the lake, but in general the rock is covered by drift deposits. Toward the north the syenite increases in amount, compared to the mica-schist.

At the clearing for a cabin, near the S. W. corner of sec. 25, 63-17., on Avis island, are large exposures of mica-schist dipping south, but nearly vertical, veined with syenite and quartz, and crossed by fine seams and ridges. This is at about thirty feet above the lake.

In the north part of sec. 36, 63-17, on the island, the same rock as the last appears, standing conspicuously, nearly vertical, but dipping in one place toward the south, and at another toward the N. W. It is cut by frequent dikes of syenite. This N. W. dip, so-called, is illusory, due to a system of joints that cross the formation.

On the N. W. ¼ of sec. 36, 63-17, the syenitic rock prevails at several points on the coast, but includes angular pieces of mica schist, as shown by Fig. 33. In some places the schist prevails

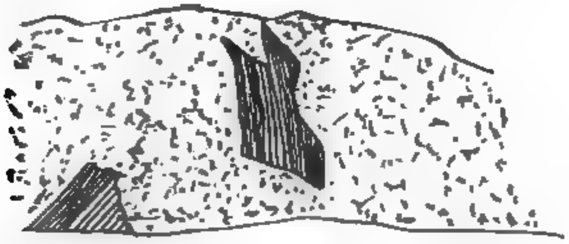


Fig. 33.—*Showing angular pieces of mica-schist included in syenitic rock on Avis island.*

and is simply cut by dikes of the light-colored rock, the dikes being of irregular shape and not constant in direction, but prevailingly conformable with the strike of the schist, which is about E. and W., or rather somewhat S. W.

Samples No. 923 show the manner of contact of the mica-schist with the syenite, obtained near the centre of sec. 35, 63-17, at the southwest corner of Avis island.

The dip on Avis island, along the southern shore, seems to be generally to the south, but this observation is unsatisfactory on account of the broken conditions of the schist. In the little channel west of the island it is more plainly seen, and is unmistakably toward the south. Mr. Stacy, who examined the west side of this channel, in sec. 35, obtained near the S. W. ¼ of the section, rock sample No. 924, which is a real granite. He also found sample No. 925, which appears in the midst of the granite in a manner similar to that of the mica-schist, but has the general aspect of graywacke. It is a very fine-grained mica-schist.

Outlet bay. This name is here given* for convenience of reference and description, to the bay from which Vermilion river flows, including its extension southwestward through the central part of T. 63-17.

Along the N. E. ¼ of sec. 23, 63-17, where the rock is not hid by boulders, it dips N. 20° E., this being a change of 135° from what it is further south. The granitic rock in it is not so prevalent as when the dip is south; still it holds scattered small veins, and irregularly shaped nests of the same kind of rock. The amount of the dip is about 40°, and is quite plain.

In the southern part of sec. 13, 63-17, on the shore-line running N. and S., is a mixed rock, made up of confused and broken masses of mica-schist with its foliation more or less obliterated, dikes — mainly narrow — of the usual syenite, and white quartz. The direction of the main strike, if there be one, can not be made out. owing to the brecciated and confused condition of the rock. Some areas of rock that resemble mica-schist, are a fine gneiss, or a gray micaceous quartzyte.

In the northern part of sec. 13, 63-17, are some other confused outcrops. The mica-schist becomes converted to a hard, dark-colored rock, with only a gneissic foliation, or with no foliation. Boulders containing both these kinds, evidently from the formation not far away, are seen frequently on the shore. The shore line mainly is of boulders. In one place the dip of the mica-

* It was first applied in the report for 1880, p. 100.

schist, with its embraced syenite, seemed to be changed again to a southerly direction.

In the S. E. ¼ of sec. 11, 63-17, is an exposure of syenite and mica-schist, the former making the larger part of the mass. It stops up irregularly from the water, the entangled mica-schist dipping N. W. at an angle of 40° from the horizon.

At the outlet of Vermilion lake, which is near the north line of sec. 11, 63-17, there is no rock exposed plainly above the surface, nor is there for some distance toward the south. On the east side of the narrow bay that leads to the outlet, about a quarter of a mile from the beginning of the rapids, is a knob or boulder-like prominence, about twenty feet long and perhaps ten feet high, whether rock in place or not I am not sure, which consists of syenite and hard mica-schist, or dark gneiss, similar to much that is seen along the same coast-line further south, on the border of transition from the foliated, supposed sedimentary, to the massive and possibly eruptive. Along the rapids the water tumbles over boulders, mainly of syenite with a few of the other massive crystalline rocks. In 1878 I concluded that the underlying rock in the rapids is mica-schist, having seen numerous fresh pieces in the channel. On the portage trail, which is on the east side, some large boulders are seen, forming low elevations that otherwise perhaps contain rock in place, but no outcrops are visible throughout the distance passed on the trail.

The country is drift-covered and wooded, largely with pine but also some aspen, some oak, occasionally an elm, spruce, balsam, ash, and soft maple.

It is more than probable that the underlying rock, at the commencement of the rapids, is a "granite" or syenite, mingled with angular fragments, and large masses, of mica-schist. Such rock makes the most of the boulders, and some slabs of more or less interbedded, freshly ruptured (i. e. not rounded) mica-schist, near the upper landing, and on a "point" on the west side, as well as at points already noted, serve to confirm this. Again, not far from the outlet, on the west side, rock which is apparently *in situ* can be seen under the water, though in the forms of angular slabs.

Further south, on the west side, near the east half-section line, in sec. 11, 63-17, rock appears to be *in situ*, though consisting of an isolated knob or tongue, rising abruptly from the water, and extending not more than twenty feet. This consists of syenite and mica-schist, the former making more than one-half of it all. The average dip is N. or N. N. E.

At the S. W. ¼ of sec. 11, 63-17, on the south side of the bay from the last, is a good exposure of the same rock. It is made up of mica-schist and syenite or granite. It rises, inland, and reaches the hight of 30 feet, more or less, at a few rods from the point. It is difficult to make out the strike or dip, owing to the confused mixture of the two rocks. Yet the direction of the little tongue of rock (as well as at the last point noted) which shows a prevailing trend E. and W. and a distinct dip in some places to the north, to the amount of 50° from the horizon, all indicate a north dip for the formation here.

On the north end of the island, at the section line between secs. 11 and 14, 63-17, the rock is prevailingly mica-schist, but it is mingled with the same light-colored syenitic rock. If there be any dip at this place, it is toward the south, as there is an elongation of structure east and west, with interleaved veins of granite dipping in that direction. A little further west, however, and south, on the same island, at a knob of a point, the rock is so confusingly mixed that no structure can be determined. The same is true also at the next little point on the same island, the rock being almost entirely of syenite.

On the point near the centre of sec. 14, 63-17, the rock is partly a breccia. This round point has three exposures; the northern one is this breccia, with no direction of dip or strike. At the next, toward the south, the rock is gneiss, or hard, closely jointed mica-schist, or micaceous quartzyte, with a strike E. and W., and nearly vertical, or dipping north. At the third the rock is evidently a bedded one, with little disturbance. It varies from a hard gneissic mica-schist to a fine, hard, almost flinty, gray, micaceous quartzyte, with a dip of 35 to 40 degrees toward the north. This is rock numbered 879. These exposures are all small, from 20 feet to 50 feet, along the beach, and do not show their relations to each other, by direct contact; but the dip seen in the last mentioned would indicate that it lies lower than the other two.

Still further south, about ¼ mile north of the south side of sec. 14, 63-17, is a sharp, rocky point, projecting east, made up of mica-schist and conformable layers of gneissic mica-schist, and some syenite dikes running in the same direction, all showing a very evident dip N. (exactly) of about 40 degrees from the horizon. In this are not only large conformable (or nearly conformable, layers, or dikes, of syenite, but also small isolated and lenticular nests or nodules, of syenite (No. 880). These latter

swell out so as to interfere with the foliation, which here is the bedding structure. It is very evident here that *a bedding structure is the cause of, and is converted into*, the foliation, producing a gneissic structure. Both can be seen in the same rock mass. This is the same as observations made elsewhere in this report.

Still again, at the section line between secs. 14 and 23, 63-17, the same rock, and the same dip can be seen abundantly displayed. But the dip here varies to 10° east of north. The dikes do not all conform to the bedding, but some times cut it zigzag. The bluffs here rise about thirty feet, and are all made apparently of this mica-schist.

Syenite, massive or only jointed, constitutes the coast from near the N. E. corner of sec. 22, 63-17, southwestwardly, as far as the southeast corner of sec. 29, except when hid by boulders, which latter is nearly two-thirds of the way. There can be seen nothing but boulders, on the shore, eastward from the Bear narrows, through secs. 32 and 33, 63-17, and to the S. W. ¼ of sec. 27, where the islands consist of mica-schist dipping south, 30° from the horizon. Northwestwardly, through the same section, boulders form the shore, except at two points where similar mica-schist outcrops, as far as to sec. 23, 63-17.

On the west side of Oak island, which is the large island in the S. W. ¼ of sec. 23, 63-17, is a large outcrop of confused rock, mica-schist changing to gneiss, cut by dikes of syenite, rising about twenty feet above the lake. No. 938 illustrates the fine-grained condition assumed by the mica-schist in some small areas. South of Oak island the rock of the west shore is hid by boulders nearly to Avis island, but on the east shore are seen several outcrops of mica-schist variously intersected by dikes.

Bear narrows and West bay. At the S. W. ¼ of sec. 29, 63-17, on the shore is a fine exposure of syenite, in which can be seen a narrow greenstone dike running E. and W. two and a half feet wide, and some included mica-schist in the syenite, this being the first instance of mica-schist in the syenite since leaving the N. W. ¼ of sec. 23, 63-17.

The rock is much obscured at the Bear narrows by drift, but it is seen occasionally along the shores on both sides of the lake, and also on some of the numerous islands, being syenite or granite.

Rock 936 is from a small island at the N. W. corner of sec. 32, 63-17. This is somewhat gneissic, and sometimes rather dark for granite.

On the N. E. ¼ of sec. 31, 63-17, a large greenstone outcrop appears, (No. 926), but its contact with the rock of the country can not be seen.

The same rock (syenite) extends through secs. 25 and 24 and into sec. 23, in the next town west (63-18). Near the centre of sec. 23 was obtained sample No. 927.

With but one small exception the rock remains the same through sec.13, 63-18 northeastwardly, and along the south shore in sec. 18, 63-17.

At the S.W. corner of sec. 9, 63-17, is a rock dipping north, containing syenite in lenticular and conformable sheets, some of the sheets being only a quarter of an inch in thickness, and some six inches. The sheets seem to originate in the schist. This rock has an evident bedding structure, dips about north at an angle of about 45 degrees, and seems not to be a mica-schist, but rather more a graywacke. A patch about a rod square is exposed.

Across the bay, northward, on the corresponding point, the exposed rock is a regular mica-schist, nearly vertical, but dipping (apparently) nearly south 85 degrees— not much exposed. Further west, at the fork of the bay, is a rocky knob, 25 to 30 feet high, which consists of mica-schist, plainly dipping south 80 degrees, with homogeneous, small and conformable veins of granite. The same dip continues through sec. 8, 63-17, along the north side of the bay, and in the island in the N. W. ¼ of sec. 8, the rock remaining about the same in character. The geologist can not fail of being struck, however, with the fineness of the interleaved beds of granite or granitic rock, with the mica-schist or gneissic mica-schist, indicating the origination of the former within the latter.

Near the point, on the north shore, near the centre of sec. 7, 63-17, the dip changes to 45° N. E., and this dip continues so far as can be ascertained, through sec. 7.

In the N. E. ¼ of sec. 13, 63-18, the mica-schist along the shore is much interleaved by fine conformable sheets of granite, and rises boldly from the water all along, or overhangs, with a marked and persistent dip N. or N. E., about 60 degrees, reaching a height of 35 to 50 feet. About fifteen rods from the shore are two little islands of granite,* rising about eight feet above the water. These must underlie the schist, when the schist extended so far. This granite, in the islands, has a gneissic foliation dipping E.

* The terms granite and syenite are not used here with careful discrimination.

N. E. The mica-schist extends to some distance west of these islands, but is replaced in about half a mile by the same kind of gneiss as that of the two islands. This is also replaced by mica schist a little further west, rather indicating an alternation of these rocks, though this relation is not demonstrated by connected observations.

Following the mica-schist bluffs westwardly, noting the fine, conformable and increasing number of their sheets of granite, the fact suddenly flashes on the observer that the *rock has become changed to a reddish-gray gneiss*, and a moment's further examination only is needed to show *its further conformable transition to granite*, thus making a conformable passage from one extreme to the other. This interchange is as gradual, and more regular, than that seen to take place between the jaspilyte and the sericitic schists north of Tower. The mica-schist, even after it has become a gneiss, is cut by thin dikes of other, redder granite which is not gneissic but coarsely crystalline. This transition is most beautifully and conspicuously exhibited on the bluff-face at the N. E. corner of sec. 14, 63-18, not far west of the section line.

Rock 929 represents the mica-schist, not gneissic, i. e. not having granite interlaminated, as above.

Rock 930 represents gneissic-mica schist, as above.

Rock 931 represents gneiss, as above.

Rock 932 represents granite, as above.

These numbers were all obtained at the same place, and within a space of forty or fifty feet, the intervals being ten to fifteen feet, all being from conformable beds.

The schist bluff falls away, and after a low spot in the bay, the same transition is repeated along the shore a little further south and west. After an interval of granite at the shore this passes inland, rising higher, and rock 933 appears at the water's edge, dipping in the same direction, showing the same kind of conformable interstratification downward, demonstrating the existence of a large mass of granite *conformably interstratified in mica-schist, and graduating into mica-schist*, above and below. This lower mica-schist is crumpled somewhat.

There are several other transitions, up and down, not all of them revealing granite, but a gneiss, or a gneissic mica-schist, in the shore line along sec. 14, 63-18.

There is much exposure of rock in the N. E. ¼ of sec. 15, 63-18, consisting of mica-schist, often very fine-grained, almost a

dark gneiss, more or less cut by greenstone, and by dikes of granite, the dip changing, with the coastline, toward the W. N. W. The numerous islands are made of the same rock. Rock No. 930 is a sample of granite that is plainly intrusive, i. e. unconformable in its direction, in the mica-schist, obtained at the N. E. ¼ of the N. E. ¼ of sec. 15, 63-18.

Similar schist and gneiss are exposed frequently along Partridge river in secs. 10 and 11, and about the shores of Partridge lake. At the narrows of Partridge lake, in sec. 12, 63-18, on the south side of the lake, a change occurs in the rock and in the dip, the latter being indistinct, but toward the south, or nearly vertical; and the former an aphanitic, hard argillyte; sometimes being cut by, or interbedded with, gneiss of a dark color.

The little island in Partridge lake, near the section line between secs. 11 and 12, is a breccia of mica-schist cemented by quartz and impure quartz, evidently all of chemical origin, some of the cement resembling veins or dikes of the pink or white intrusive granite, suggesting that many, if not all of the unconformable dikes in the mica-schist may be of chemical origin, while the interleaved gneiss, and dikes (so-called) of granite that grade into the mica-schist, are plainly of the same nature as the mica schist, and hence of sedimentary origin.

Rock No. 935 represents some of the impure quartz* from this little island, but it does not fairly represent some of the more granitoid quartz, seen in some of the veins. *It seems there must be some distinction observable, or discoverable, between the dike-granite and the gneiss-granite.*

The direction of the group of islands running through secs. 15 and 21, 63-18, is that of the strike of a great series of hard, gneissic mica-schist, with granite beds and some dikes, the dip gradually becoming N. W. then W. and passing to the point where Wakemawup's village is located. This belt immediately overlies a great formation of granite, as shown not only by observations recorded above, but also by little outlines of the granite in islands lying just east of the Big island. From one of these outliers situated in the N. W. ¼ of sec. 22, 63-18, was obtained rock No. 937. Mr. Stacy examined the extreme northwest extremity of the lake, extending from Wakemawup's village in sec. 21, 63-18, *northwestwardly and northeastwardly* through secs. 20, 17, 9 and 10. He reported finding only rock like that already

* Unfortunately this specimen was lost.

described, viz.: mica-schist interbedded with gneissic rock, and cut by veins or dikes of granite. Sometimes the bluffs rise, in this part of West bay, to the hight of 20 or 30 feet. Along the southwest shore the rock is hid by drift, and boulders constitute the shore line.

The south shore of West bay was examined also by Mr. Stacy. It is chiefly composed of drift, particularly through secs. 27 and 26. In sec. 25, and on the islands in the southeast part of sec. 26, are outcrops of granite or gneiss.

The north shore of Vermilion lake in Towns 63-15 and 16. Along the south side of the long point which projects S. W. in sec. 31, 63-16, the rock rises sometimes twenty or thirty feet directly from the water. The rock is mica-schist. It stands nearly vertical but dips southerly (20° E.), i. e. toward the lake, the strike being parallel with the shore. The bedding planes intersect a system of coarse jointage planes that slope in the same direction but run more nearly east and west. When large slabs separate from the bluff in accordance with these planes, and the remaining surface gets weathered, the lines of intersection with the alternating harder and softer layers of the sedimentary bedding, bring out a striation on the weathered face of the bluff that has a deceptive appearance of sedimentary dip, about 45° from the horizon toward the N. W. In passing along, an observer would be likely to take this for the dip, unless he made close examination. That this is not bedding structure is here evident from the fact that there is a true sedimentary structure visible-dipping as stated; and also from the fact that sometimes on the same bluff, a little further toward the east or west, can be seen a similar striation—somewhat wavy—dipping in exactly the opposite direction, produced by a different set of jointage with the true bedding, this set running across the bedding in the direction S. S. W. There is a hard structure, or series of veins of a light color, running all through this rock and forming a network of relief-ridges that cross and recross each other like Widmanstätten figures in a meteorite.

In this mica-schist, further, are dikes of light-colored syenite (or granite) running about east and west, but varying in direction. The color of the schist also varies from nearly white to very dark, by reason of numerous bands that penetrate it coincident with the bedding. These shade through various tints of schistose rock to syenite or granite apparently being perfectly crystalline. This schist has a very evident sedimentary struc-

ture. It is firm and even shows an approximation to gneiss, the foliation of which is then the same as the bedding structure of the schist. When, however, this gneissic structure comes on, the grains are finer than in the gneiss, the color is darker, but the striping, due to sedimentation, is still preserved. The dikes are from two to eight feet wide. Rock No. 13 (H) is the mica schist, and 13 A (H) represents the white dike-rock. Number 13 B (H) is a green trap or diabase which forms narrow dikes in No. 13 (H). This is a very common feature of the bluff.

Shonea island, so named by the Indians from the mining operations carried on for silver near the north side of it in 1866, lies in four different towns, just south of the high peninsula just described. The rock is a hydro-micaceous schist with numerous quartz veins and nodules. It seems to be near the dividing line, geographical as well as lithological, between the mica-schists of the *Vermilion series* and the graywackes and sericitic schists that lie further southeast. It is much obscured by drift, but the dip and strike seem to be conformable with that of the mica-schists lying next north.

The islands lying toward the N. E. from Shonea island in sec. 31, 63-16. consist of an intermediate, greenish, sericitic schist.

Dike-rock [like No. 9 (H)] appears on a small island in the S. E. ¼ of the S. E. ¼ of sec. 31, 63-16. It here runs through a green argillitic slate (939) somewhat crumpled, dipping south in the same manner as the mica-schist seen on the mainland next north, about 75° from the horizon. This schist contains nodules of white quartz somewhat conformable with the dip, as the jaspilyte quartz occurs in the green schist. This green slate seems to graduate into the sericitic schist. It appears again on the south side of the large island in the S. W. ¼ sec. 32, 63-16, and at the N. E. corner of the same island, constituting apparently the continuous course of one or more dikes.

On the S. W. corner of the large island in sec. 32, 63-16, a small dike has a somewhat exceptional appearance. It is represented by No. 12 A (H). and it cuts through — at least it runs in — No. 12 (H). It is porphyritic, and very different from the rock in which it runs, yet it extends in a direction coincident in a general way with the schistose structure, and with the bedding. It varies in width, swelling out and pinching up. At the west end of the island it ceases abruptly, as if it had been faulted since its formation. There are also small lenticular patches of the same kind of rock, running in the same direction, in the

country rock, these being not over half an inch in width, or less, and continuing but a few inches. The weathered, or burnt, surface of the dike is light red, or pink, and the crystals of feldspar stand out, above the surface. The dike here varies from an inch, or less, in width, to eight or ten inches. The country rock is a greenish sericitic schist, very firm, having a coarse schistose structure parallel with the bedding, and apparently dipping 80° from the horizon toward the N. 10° W. This schistose slate is rather conformably placed alongside a different green dike which also has an indistinct schistose or gneissic structure running in the same direction as that of the country rock. In this are quartz veins, and also veins of rock that resemble 12 A (H), but white and less uniform in color and direction. This is about eight or ten feet wide, and then is replaced by green schist on the north side again. This green schist is No. 12 B (H).

On the west end of the island in the N. E. ¼ of sec. 32, 63-16, are visible seventeen dikes, from an inch to two feet in thickness, in the space of sixty feet. They run about 20° N. of E. The schist through which they run has considerable mica in some parts of it; in other places none at all. On the S. E. end of the same island the schist is sericitic, and has a very little mica in it. On the east end the schist seems to be sericitic, and is very micaceous. There are dikes in it, as usual, of pinkish and gray syenite. On the point near the south line of sec. 28 the rock is more like graywacke, and seems to have no mica in it.

Through sections 28, 27, 23, 26 and 25, in T. 63-16, the north shore of the lake consists, in general, of mica-schist and granite, irregularly mingled, but these rocks show remarkable variations, the former becoming hornblendic and massive, and passing apparently into syenite or dioryte, and the latter becoming very coarsely granular, and very often red.

At the centre of sec. 27, 63-16, the schists are micaceous, and apparently chloritic, and stand nearly vertical, cut by numerous white dikes.

In the N. E. ¼ of the same section, the rock is micaceous graywacke, standing vertical, crossed in all directions by granitic dikes, though the most of these are in the direction of the bedding. The strike is ten degrees south of east. The same strike and dip appear again on the shore south of the bay situated near the centre of section 26, 63-16.

Mr. Stacy, who examined the north shore through secs. 27,

23, 26 and 25, 63-16, procured the samples numbered 940-947, to show the variations in the rock.

Sample No. 940 from S. W. ¼ sec. 23, 63-16, is not very common, and rather an extreme for coarseness; 941, from the same place, rather common; 942, N. W. ¼ sec. 25, composes a large bluff; varies to a rock like 941, both being red granites; 943, from N. E. ¼ sec. 27, from the same bluff as 940 and 941, a common rock; 944, from near the centre of sec 27, one of the phases of the rock common to the country; 945, from the S. W. ¼ sec. 23, mica-schist, hornblendic, rather a micaceous gneiss; 946, N. E. ¼ sec. 27, red micaceous gneiss.

In sec. 25, along the south side of the same bay, the rock is reported by Mr. Stacy as very nearly graywacke, but the samples he obtained are more nearly a fine mica-schist, evidently about on the verge of transition from one rock to the other; bedding about vertical. Along the north shore of the bay, extending from the town line eastward in T. 63-15, he reported that he found only graywacke, and "a graywacke slate, varying to porodyte," as on a point where a high perpendicular bluff appears on the shore in the N. E. ¼ sec. 3, 62-15, where he obtained rock 947, which is a poroditic graywacke. The slaty graywacke sometimes was seen to vary to a slaty sericitic schist. Such was seen about half a mile northwest from the place where the rock 947 was obtained.

Eastward of Pine island the north shore of the lake is caused by the extension of the hills of graywacke which begin in sec. 4, on Pine island, and these hills will rise sometimes 175 feet above the lake. On a little island near the centre of sec. 4, 62-15. the rock is a slaty graywacke, dipping 60° N. and 30° W. with no schistose structure at variance with the bedding, though cut by numerous joints in all directions. In some of its coarse beds this graywacke approximates on weathered surfaces, the appearance of some of the porodyte, especially some of the schistose porodyte. In other places, further east, it is somewhat conglomeritic, the stones being now evinced by a tortuosity of all the structural arrangements about there, and being particularly evident on the weathered surfaces.

Pine island. The western end of Pine island, through sec. 34, 63-16, has numerous outcrops of sericitic schist and graywacke, dipping toward the southeast, the land rising, at short distances from the shore, from fifteen to thirty feet. A greenstone dike is visible on the shore in the N. W. ¼ of sec. 34, 63-6, running about E. and W.

In the promontory-like point that juts out northwestward in sec. 27, 63-16, the schists are vertical, and are crossed by dikes of granite.

The islands, and the coast-line, in sec. 26, 63-16, are composed of the same rock (a graywacke which sometimes is micaceous) and is cut by dikes of light colored granite, the strike of the schist being to the south of east.

On the north part of sec. 35, 63-16, are some bare hills. These consist of micaceous graywacke, the strike being 10 degrees south of east. It is disturbed by dikes of greenstone that run about E. and W. These weather gray, like the wacke, but by fracture, and by their unconformity with the rest of the rock, they are seen to be of eruptive origin. Their width varies from three inches to thirty inches. No granite dikes are visible here. The land is about 50 feet above the lake; and though the strike is about E. and W., the hills ascend like sheep's backs running from north toward the south, ascending from the shore; and coalescing, further south, in a general elevation more bushy and scantily timbered, at about the same hight. These hills have the form of glaciated domes, but fires and frosts have destroyed the markings.

Besides the foregoing greenstone dikes, there is another kind of igneous rock here, represented by rock 881, which is a rather fine dike-rock, running about parallel with the strike, but cut by the other greenstone dikes. This weathers much lighter colored, and the course of the darker greenstone of the other dikes can be seen crossing it, though nearly parallel, by the contrasting bands of color.

At the extremity of the point that projects eastwardly from sec. 35, into the N. W. ¼ of sec. 36, 63-16, was obtained rock sample No. 882. This is coarsely schistose, and somewhat confusedly so, contains some patches of red syenite, and has a red mineral disseminated through it, but its general color is green, due to a rather soft, foliated, green mineral like chlorite, that is perhaps changed from hornblende. The red mineral is a feldspar, and the aspect of the outcrop is that of a rotted igneous rock. This may be compared to No. 12 A (H).

At the point at the narrows, sec. 36, 63-16, projecting westwardly, the rock is about vertical, runs E. and W. (or nearly) and consists of a rather micaceous graywacke, and is cut, conformable to the schistose structure, by a greenstone dike, about 2½ feet wide, which forms the breakwater toward the S. W. and makes the extremity of the point.

Boulders and slight outcrops of sericitic schist constitute the shore eastward through the rest of Pine island.

At the N. E. ¼ sec. 5, 62-15, is a fissile schist of a gray color, crumbling down under the weather, which probably underlies much of the shore further west, though unseen because of the drift covering, and the ease with which it is destroyed by the weather. It is seen here because the shore line faces the prevailing and strong westward winds, and the exposure is kept fresh by waves and drifting ice. It rises about ten feet in the bluff. It contains lumps of black chert or hornstone. This rock is No. 883.

The southeastern extremity of Pine island is very rough, the hills near the shore rising fifty or seventy-five feet above the lake. The rock here is mainly graywacke varying to sericitic schist, also becoming poroditic, the latter in the western part of sec. 4, 62-15, and the eastern part of sec. 5.

At the S. E. ¼ of sec. 6, 62-15 (E. side of the bay), the graywacke (?) has a massive structure, and sometimes a basaltic jointage, approaching porodyte. It is represented by sample 920. It contains crystalline grains. It dips N. 80°. On the weathered and glaciated surface the sedimentary banding is visible, and beds of argillyte, and angular, isolated pieces of argillyte, can be seen distinctly, embraced unconformably in the granular graywacke, but not on so grand a scale as those seen on sec. 20, 62-15.

A little north of the point, within the bay, on the east side, is a low exposure, on a small low point, of a greenstone dike, the dike being about 20 feet wide and apparently running in the same direction as the schists.

At the entrance to the bay, on sec. 6, 62-15, on the south side of the island, the same kind of graywacke appears on the west side as on the east. The rock is hard and tough and has nodules and straggling veins of chemical quartz.

At the S. W. ¼ of sec. 6, 62-15, where the town line crosses the shore of Pine island, is a large lot of clay slate, which has the appearance of being economically valuable. It is black, and purplish black. Large blocks lie on the beach. It rises also into the adjacent bluffs, ten to twenty feet high. Sample 921.

On the shore S. W. ¼ sec. 1, 62-16, is a greenstone dike cutting argillyte, but in the highest part of the ridge, which rises about 40 feet, while the general facies of the rock is that of greenstone, and it seems to have sufficient toughness, its color

and fine granular texture resemble those of some fine graywacke. It is only after considerable examination that an opinion can be formed as to the nature of this rock. Sample No. 922 represents this indefinite rock. At the section line between secs. 1 and 2, a little further west, this rock rises in a cliff, breaking off toward the west. It is here plainly a hardened sedimentary rock, exhibiting the regular sedimentary banding. In most of this exposure this rock appears as a hardened and basaltified graywacke and argillyte. It is distinct, however, from the greenstone dike mentioned, which runs westward through it.

The rounded point which extends southward from sec. 2, 62-16, into sec. 11, consists of drift, and the shore line shows only boulders and gravel. Graywacke, alternating with stretches of sand, or of boulders, with marshy spots in the bays, extends thence northwestward to the north line of the town.

The island which lies in secs. 11 and 12, 62-16, has frequent exposures of graywacke. On the northwest coast it verges toward argillyte.

Ely island. The following notes on Ely island were made chiefly by Mr. H. V. Winchell.

On the south half of sec. 17, 62-15, the rock has the same structure as No. 2 (H). It is, however, finer-grained, and seems to be more "talcose," but it contains occasional grains of free quartz. The schistose structure runs about ten degrees north of east. The bedding is not apparent, but the schist stands vertical.

In the S. E. ¼ of sec. 17, 62-15, this rock holds more numerous grains of quartz. In some places, but not generally, there is an evident basaltic structure. There are also seen here pebbles of No. 2 A (H). On one of the highest knobs the free quartz granules are about as numerous as in No. 1 (H), and there are other pebbles, six inches in diameter, of quartzyte and other hard rocks, compressed, or worn, so as to agree with the schistose direction of the rock. No. 2 B (H) are pebbles from this felsitic conglomerate. Veins of white quartz run in various directions through it, principally east and west. In one place, about on the S. E. ¼ sec. 17, such veins are only a few inches apart, and vary in thickness from one to six or eight inches. This rock weathers into thin scales, finely broken up and nearly always parallel with each other.

Boulders of granite, mica-schist, syenite, etc., are found on the top of the highest parts of this island, sixty feet or more above the lake.

In the N. E. ¼ sec. 20, 62-15, the felsyte gives way to the graywacke, which has its bedding and schistose structure both running east and west, standing vertical or perhaps dipping to the north. The felsyte lies unconformably on the graywacke.

At the S. E. ¼ of the S. E. ¼ of sec. 17, 62-15, west of the bay, the two rocks come together and mingle with each other. There seems to be an alternation of graywacke and felsyte in several successive beds, the graywacke prevailing in one direction and the felsyte in the other. The sedimentary bedding of the graywacke runs 35° N. of E. and the schistose structure E. and W. The section line between secs. 16 and 21 is about the line of division between the felsyte in sec. 16, and graywacke in sec. 21. They lie side by side on the east side of the bay, corresponding to the same position on the west side.

On the east side of the point, in the S. W. ¼ of sec. 16, 62-15, the felsyte lies unconformably on the graywacke. At the same place the former changes from a homogeneous mass of rock to a conglomerate containing rocks but little changed from their natural state.

The felsyte continues along the shore in the S. E. ¼ of the S. W. ¼ sec. 16, 62-15, but it is not so homogeneous. There are patches where it is quite conglomeritic, the schistose structure continuing E. and W. There are portions of it, sometimes ten feet in width, and of indefinite length, running in the same direction as the schistose structure, which are much softer, and are generally much decomposed, and fallen down, as though there were a mineral in it much softer than that of which the rock is generally composed.

On the south side of the island, in N. E. ¼ of sec. 15, the felsyte changes into a fine-grained greenstone, varying from quartz-dioryte to slate. Around on the end of the point it changes back to the light-colored homogeneous felsyte, containing a few free quartz grains. On the north side of the island, in sec. 15, 62-15, the underlying rock is not so much exposed, as on the south side. It is all the same kind of rock, varying between felsyte and conglomerate.

In the S. E. ¼ of the N. E. ¼ of sec. 16, 62-15, the conglomerate has a schistose structure running about 20° N. of E. There are in it pebbles of jasper, red and black, quartz grains or lumps, and pieces of rock like No. 3 (H), which is a sericitic (?) schist varying in the coarseness of its structure from a rock that resembles No. 1 (H), to slate. It may contain lime.

In the N. E. ¼ of sec. 17, 62-15, the rock rises high, forming rough hills. These hills are rounded somewhat but have been roughened since. The north sides of all these knobs are more decomposed than the south sides. The rock is about the same as that of which the island is chiefly composed, but here it weathers whitish, while further east it has chiefly a greenish color when weathered. In it are the same pebbles as usual, and some pyrites. None of those greenish pebbles found on the mainland south of the lake, and numbered 2 A (H) are here to be seen.

In the south half of the N. E. ¼ of sec. 17, 62-15, there is a quartz vein in this rock ten feet thick. It does not appear to be very long, nor to contain anything but occasional lumps of the rock itself. It has been blasted "for gold" for a length of thirty feet or more. It occupies a rough jointage opening in the felsyte, dipping northeasterly about 75° from the horizon.

On the point in the N. E. ¼ of the S. W. ¼, sec. 17, the graywacke again is found. It has a dip to the north and an east and west schistose structure. It does not rise over fifteen feet above the lake. As the west side of the point is reached the felsyte again appears, forming the whole of the west half of the point rising about 20 feet above the lake.

The east end and the south shore. Along the north shore of Mud Creek bay are occasional exposures of graywacke. Hills of the same rise from 50 to 70 feet above the water near the bay. On the south shore, near the mouth of Mud creek, is a hill about 125 feet high, and this extends, with slight variation, for nearly a mile toward the west. into sec. 12, 62-15. Graywacke dipping N. 70°-80° appears on the shore on the point in the N. W. ¼ of sec. 12. The islands in the bay are composed of the same rock, with a strike nearly E. and W.

In the southern part of sec. 12, 62-15, a large outflow of eruptive greenstone makes its appearance (875). It has an indeterminate width, and only a conjectured direction. It shows for nearly 200 feet, and makes a bold, high eminence, from which the large basaltic (or roughly and coarsely jointed) blocks fall down on the beach, the hight of the shore here being about 35 feet. The conglomerate, through which it seems to cut, is blackened and hardened on the south side, for a distance of eight or ten feet.

The exact point, which sharply projects on the south side of the next bay north, is made of conglomerate; but a short distance within Mud Creek bay, on the south side, the slaty graywacke makes its appearance.

The quartz which is seen near the north line of sec. 13, 62-15, is of small extent. It is white, and appears conspicuous from the lake, in passing along. It runs in an irregular ascending deposit about 40 feet. and pinches out at both ends, being about four feet wide near the middle. To the north some quartz deposits of the same kind are visible, in smaller areas, following the irregular, angular openings that were made in the formation, when it was fractured. The inclosing rock, just at the "vein," is a siliceous graywacke or porodyte, dipping north uniform with the dip in this part of the country generally, but it soon changes to the arenaceous porodyte, or conglomeritic porodyte (also styled felsyte) so common about the east end of Vermilion lake. In about a couple of rods further north, on the highest part of the hill, this conglomerate is broken, and mingled with a broken graywacke, the bedding planes of the latter being warped, and, over an area of a rod, having a distinct dip toward the east. In this vein is seen a little bornite and chalcopyrite, but it has not been worked any more, since I visited it eight years ago.

The felsitic conglomerate, or conglomeritic felsyte, already spoken of, forms the underlying rock toward the south, and about Armstrong bay, but is hid badly by drift and by forest.

This poroditic rock, generally containing rounded boulders, extends through the islands and coastline, from the head of Armstrong bay westward to Stuntz island. There were noticed only two points at which there is any variation.

One consisted of a thin layer of rather more fragile schist, lying between a dark gray quartzyte, on the north, and the conglomeritic felsyte on the south. This was in the northern part of sec. 13, 52-15. The other was on the N. E. ¼ of sec. 22, 62-15, on a small island, where, as well as on the main land east of the island, a quartzitic, dark graywacke, was seen standing in nearly perpendicular coarse jointage somewhat coarsely slaty.

Everywhere, about the S. E. end of the lake, when any dip is visible, it is toward the north, generally 80°-85°, but at one of the small islands in sec. 21, it was seen as low as 60 degrees.

Stuntz island rises from 25 to 30 feet. It is in the east part of sec. 21, 62–15, and forms a bar across the entrance to Stuntz bay, leaving but narrow passages at the ends. It exhibits several very interesting geological features. The shape of the island is something like the figure below (Fig. 34). The southern, more elongated, part is made up of the conglomeritic felsyte, mentioned, and the shorter peninsula, on the north side, is of the

S. *Fig. 34.*

Fig. 34.—*Showing Stuntz island.*

same felsyte sometimes with a basaltic structure, and sometimes with free quartz but not conspicuously conglomeritic. In the conglomeritic portion are two sets of dikes, the main one consisting of one large dike and several branches and narrow wedge-shaped masses of doleryte, running E. 10° S. Sample 872 represents it. See also a photograph.

The rock of the other set of dikes is now in the condition of a greenish chloritic schist (see rock 873). This series is not so conspicuous, nor so numerous, as the other, but shows two distinct narrow dikes about eight and eighteen inches in width, running ten degrees north of east, thus forming an angle of twenty degrees with the other set. It was for some time a matter of doubt whether these were true dikes. They manifest a schistose structure parallel with that of the felsyte, and also parallel with the bedding structure of the region so far as any such is visible. They are soft, easily shattered, and also appear as short, isolated belts, sometimes not running more than ten feet before they pinch out, though one of them can be followed a distance of more than sixty feet, when it becomes invisible by running under turf and bushes. In one case one of these splits, and forks round a portion of the conglomerate. One fork dies out quickly, but the northerly one continues for twenty feet, before it is lost under the soil and vegetation. They also contain a few fragments of jasperoid quartz, and rarely some rounded pebbles of more coarsely crystalline rock like themselves, or like the rock of which they, perhaps, originally consisted. That which furnished finally incontestable proof that

this system also constitutes a series of true dikes was the discovery, after clearing away the turf, that they cut the other dikes, maintaining their identity of structure, and their walls intact right across them. They must therefore not only be true dikes, originally crystalline doleritic rock, but they must be of somewhat later date. The dike-like character of the other system is most evident, not only in the manner of crossing the formation, and forming angular jogs, but in the basaltic form of the rock and its doleritic nature. The mineral nature of the later system seems now to differ from that of the older only in being more changed by decay. This may be due to the accident of its direction being coincident with the subsequent development of the schistose structure, allowing not only a complete fibrous internal rearrangement, but, afterward, a more ready access to all disintegrating agents. No. 873 A is a rounded ball of green rock taken from the second system. Only two or three of these were seen. In both series can be seen pieces of jasperoid rock.

The conglomerate itself is coarse, some of the stones being more than a foot across. Stones make up the whole of it, in some places, but in others they are small and scattered, or fail entirely. There is, even in the coarsest portion, a little schistose, sericitic (?) material, with all its scales and fibres elongated in the direction of the greater diameter of the pebbles, that twists about between the boulders, its laminæ about parallel to the sides of the inclosed stones. The stones and the matrix have a general similarity or approximate identity of mineral composition and color. The weathering color, particularly of the stones, is nearly white, but there is a dull greenish tinge, in the matrix. On fracture, a light green color is at once apparent in the stones, and a darker green, or a grayish green, in the matrix. The stones contain much semi-rounded quartz, in grains of all sizes up to one-sixteenth inch across, while the matrix not only contains these, but seems to be porphyritic sometimes with white feldspar. The pebbles themselves are chiefly a greenish felsyte and show a fibrous internal elongation in the same direction as that of the matrix, but they are more durable than the matrix, and often stand out distinctly on the weathered surfaces.

This conglomerate also contains many pieces of jasperoid quartz showing a fine banding like that in the ore-rock of the mines. Sometimes this is placed across the schistose structure, but it generally is parallel with it, and the pieces then seem

to have the same superinduced lengthening in that direction which is evinced by the rounded boulders of the other kind of rock. This seems to show unmistakably a difference of age between the jaspilyte of the hills and the sericitic schists associated with it, and this conglomerate.

The lengthening, or compressing, of the stones in this conglomerate need not all be attributable to the effect of the superinduced schistosity, which must have been caused since the later system of dikes, since if any stone, whatever its source or nature, not absolutely round, be cast into a liquid, whether water, mud, or ash, it would assume a position, when it came to rest at the bottom, approximately with its flattened sides, or at least with its elongation, parallel with the bottom on which it came to rest, and would remain so, in whatever direction the bedding might be tilted. There is no evident sedimentary structure in this conglomerate, but there is a coarse structure, somewhat wavy, simulating a succession of sedimentary or other manner of accumulation, which dips toward the south or stands nearly vertical.

No. 872 A was taken from the side of a narrow dike of the main system on Stuntz island. This dike is not more than 1½ inches thick where the piece was taken off, and pinches out entirely toward the west further, in about ten feet.

In the northern part of Stuntz island are veins of quartz up to a foot in width, running through the felsyte. The felsyte runs parallel with the conglomerate, and merges into it. Some light-green serpentinous pebbles are here seen in the felsyte, represented by No. 2 A (H), the felsyte being No. 2 (H) and 874 B. These bits of light-green rock are uniformly elongated with the schistose structure, and their schistose structure runs in the same direction, but is, of course, much finer. These bits seem to be referable to some basic greenstone outcrop which supplied fragments to the conglomerate as it was forming. By the elongating, and schistizing and weathering agents to which they have since been subjected, such bits have been converted, not into the homogeneous porodyte, or felsyte, but into these serpentinous, soft, green, pieces, because of a difference of original mineral character. This hypothesis is strengthened somewhat by the existence of what appears to be a piece of olivinitic greenstone (874 B) in this felsitic rock in such a position as to have been protected partly, from change by some large quartz veins that lie adjacent. This,

however, was not in agreement with the schistose structure, but conformable to the quartz vein, which ran across the structure.

On close inspection of the rock that forms the northern half of the island, although it is apparently entirely homogeneous, yet in nearly all parts there is an indistinct interval structure, evinced by faint blotches of lighter color and by warping of the laminæ of foliation about such invisible shapes within the rock-mass, that shows there were conglomeritic fragments, of about the same material as the matrix, continually being added to the forming rock. These are now so blended with the surrounding mass, and so nearly identical in composition and grain, that they can be identified only when the process of weathering, that unerring detective ally as well as most successful deceiver, of the geologist, brings their forms partially into view. In this part of the island, however, are seen none of the jasper fragments that are so common in the southern. The rock, instead, contains in some places much free quartz, some of it being in coarse grains even as large as a quarter of an inch in diameter, not evidently as perfect crystals.

Since the quartzyte and jasper pieces in this rock are placed with their elongated axes parallel with the schistose structure, and also parallel with a rude foliation which might be called bedding, but do not partake of the schistose structure, and are not changed from their original angular shapes, it is evident that the general elongation of the boulders in the mass in the same direction is not due to the schistizing process, but that they assumed the position that they have, as well as the forms that they exhibit, prior to, at least independently of, that process, and under the action of some force more powerful and more widespread than it. It could be no other than that which originated the conglomerate rock itself. On the supposition that this foliation is the original sedimentary bedding, it is easy to understand that under the action of sedimentation, all stones would lie on the bottom flatwise—or nearly all—and that they would agree in their principal dimensions, with the bedding planes. This force then may have put all these stones in the sediments in a uniformly flat direction, coincident with the bedding and none of them may have been changed in shape since they were deposited.

If the structure referred to here as foliation be not the result of true sedimentary bedding it must be due to a semi-fluid condition of eruptive rock, in other words a *flowage structure*, under which

there would be the same tendency for all hardened rocks of similar character, inclosed in the pasty or molten mass, to arrange themselves parallel with the direction of the slow movement, especially if it be one accompanied by a progressive accumulation.

In the central part of Stuntz island the structure of the rock varies in belts, along indistinct lines of contact. The rock is essentially alike in composition, but different in the fineness of the sub-crystalline grains and in the schistic structure. The finer grain and structure are apparently cut across by lines of contact with other rock, but a parallel schistose structure, though coarser, is perpetuated in the coarser rock. These are both without apparent boulders, are fine-grained, feldspathic, without apparent free quartz, and are represented by 2 (H), the coarser one embracing small lenticular bits of soft, greenish serpentinous slate. They both have an imperfect basaltic jointage. Beyond these, that is, toward the south, a coarser rock again comes in, having a similar abrupt line of contact and transition, the fine-grained belt being about 12 feet across. This has the same general color and finely sub-crystalline feldspathic composition, but is not so completely homogeneous. On careful examination and particularly on weathered, or burnt, surfaces, can be seen distinctly, small areas of lighter color and denser grain, though more porphyritic, with some elongation in the direction of the schistosity. The forms of these areas are seen to be rounded whenever their shapes are made evident by the exfoliation of the surface by the action of the fires that have rendered the island nearly bare rock, simulating those of the conglomerate, and suggesting that even within this homogeneous rock are still the nuclei of pebbles and stones, and that the whole of it may have been at first a coarse conglomerate of pebbles of one sort of rock. The following figure (No. 35) shows this manner of alternation of differently schistose belts.

Fig. 35.

Fig. 35.—Showing differently schistose belts in the felsitic conglomeration of Stuntz island.

There are, then, steps of change, so far as I can see from No. 1 (H), through 2 (H) to 874, that show that the igneous characters of such rock as is basaltic or dike-like, can be referred to a fused condition of the rock constituted of conglomeritic matter, and the subsequent mingling of the molten rock with that which was semi-molten, and that which was simply plastic, or that remained rigid. Whatever the original genesis of one, was also that of the other. Whether the fused condition was prior, or subsequent to the formation of the mass as rock, is not here considered. It is evident, from these facts, only that the coarsely fragmental state was very widespread, permeating even very fine-grained rocks, and that the evidence of heat, and even fusion, extends through both. In that sense, if in nothing further, they are both igneous rocks, but they may not have come from any deep source, like the green dike-rock of Nos. 872 and 873.

At about ten rods south from the point from which was taken the sketch of Fig. 35, the coarsely conglomeritic rock rises in great domes that show their coarse boulders by the blotches that appear on the surface, as well as by differences in texture and some variation in composition—though here also a general sameness of mineral character pervades both the boulders and the matrix.

About the shore of Stuntz bay, except where boulders constitute the shore-line, and on the islands, this conglomeritic rock, or some phase of it, is seen, with only one exception. That exception is on the point at the extreme southeast corner of sec. 21, 62-15, and on the island adjacent where bedded graywacke slate appears. It stands nearly vertical, but dips north, 80°-85°, and runs under some rock like that of the north side of Stuntz island, the latter here acting like an eruptive rock in being non-conformable with the bedding of the slates. This slate varies in strike so that in some places the schistose structure makes a sharp angle with the bedding. At this place, as well as on Stuntz island, and at Pike river falls, there is evidence of twisting and warping made since the production of the schistose structure.

The point southwest from Stuntz island is made of the same kind of rock as Stuntz island. It rises fifty feet above the water, nearly vertical, but in some places the evident structure dips toward the south. In some places it shows lenticular masses of rock not conglomeritic, quartzose with basaltic jointage, which

crowds over and cuts across the schistose structure of the conglomerate and of other rock, and plays the role of an igneous rock. This is represented by No. 1 (H), though the rock having this number was not obtained here. The rock having this igneous manner seems sometimes to be involved in the conglomerate somewhat like a dike, but really wedging out toward the east. Its contact with the conglomerate shows nothing noteworthy. There is nothing indicating any effect that it had on the conglomerate. There is simply an abrupt transition from a schistose, coarse rock with boulders to one without boulders, of about the same color, massive or coarsely jointed in a basaltiform manner, and homogeneous in mineral characters.

At the head of the small bay at the S. W. ¼ of sec. 21, 62-15, is a brecciated condition of the various schists of the region. Toward the northwest from this, on the point extending into the lake in the S. E. ¼ of sec. 20, 62-15, were made many interesting observations. Some of these have been given in the former chapter in discussing the origin of the iron ores, and some others are given below.

The point in S. E. ¼ of sec. 20, 62-15, embraces a varied geology. There is a confused breccia, or apparently a mingling at least, of graywacke, argillyte, sericitic schist, conglomerate and felsyte. Graywacke and argillyte constitute the greater part of the rock at the surface, particularly in the northern portions of the peninsula. The bedding direction of this, while distorted and reversed over small spaces, yet runs in general nearly coincident with the schistose structure, and is nearly vertical. Toward the south further, the peninsula develops into a prominent ridge elongated northwest and southeast, consisting of a coarse breccia of jaspilyte. This extends several rods, gradually acquiring more rounded pebbles of jasper, then rounded pebbles like those seen in the Stuntz island conglomerate (the jasper pebbles becoming white quartzyte), and at last, just before it disappears on the east side of the point, it presents very much the aspect of the conglomerate which forms the bold shore line on the north side of the point in sec. 21, and which extends to Stuntz island. About half the pebbles are of white quartzyte, the rest being white, quartzose porodyte. It has some bands of fine greenish schist running conformably through it, the same also forming the matrix.

Further north, on the same point, near the centre of the quarter-section, is another exposure of jaspilyte, some of it being

hematitic. It is twisted, broken, and in general has a banded strike toward the north, then to the northwest, and then about west, and suddenly ceases. It graduates, toward the north further, into the same green schist, which at once becomes a conglomerate of white quartzyte and porodyte. This jasper area, which rises so as to form some of the higher parts of the peninsula, is itself a conglomerate, as it holds some rounded as well as angular pieces. Indeed there are strata or belts of fine jasper-conglomerate, with the schist-matrix, running zigzag through the coarse mass, not conformable with the banding of the main jasper masses, but at various angles. In the midst of the whole can sometimes be seen small patches of the green schist that forms the matrix.

Apparently the green schist here mentioned is the same as that seen at the mines at Tower unconformable on the jaspilyte. It seems to graduate, on sec. 20, 62-15, into the rock No. 1 (H), which has many features of an igneous rock. This last is found a little west of the conglomerate areas last mentioned, on the same peninsula, and is associated there unconformably with graywacke and argillyte. It is not here generally spread, but a patch about 30 feet across strikes diagonally across the graywacke. It has a perfect basaltic, columnar structure, and contains semi-rounded quartz grains distributed somewhat like quartz in a porphyry, though not of uniform size. It appears as if it could have been produced by the fusion of the materials of the surrounding rock. This belt extends toward the east, but seems to divide into two parts. At a place northeast from where this rock divides, following an exposed low ridge of rock, mostly of slaty graywacke and graywacke, the latter rock is seen to change across the bedding to fissile argillyte, then to sericitic (?) schist, then to hold masses of jaspery quartzyte and black chert, the schistose structure winding about them, and filling all their sinuosities, the same as noted north of Tower. This observation shows the intimate relation between this green schist and the argillyte, one changing to the other.

In this green schist are not only large masses of jaspilyte but pebbles of granular white quartzyte, like the "chalcedonic quartz" of the ore-rock, some of the latter being an inch or two in diameter.

The same basaltic rock is found on a small island about 25 feet across, just north of the point last mentioned, but here it is finer-grained.

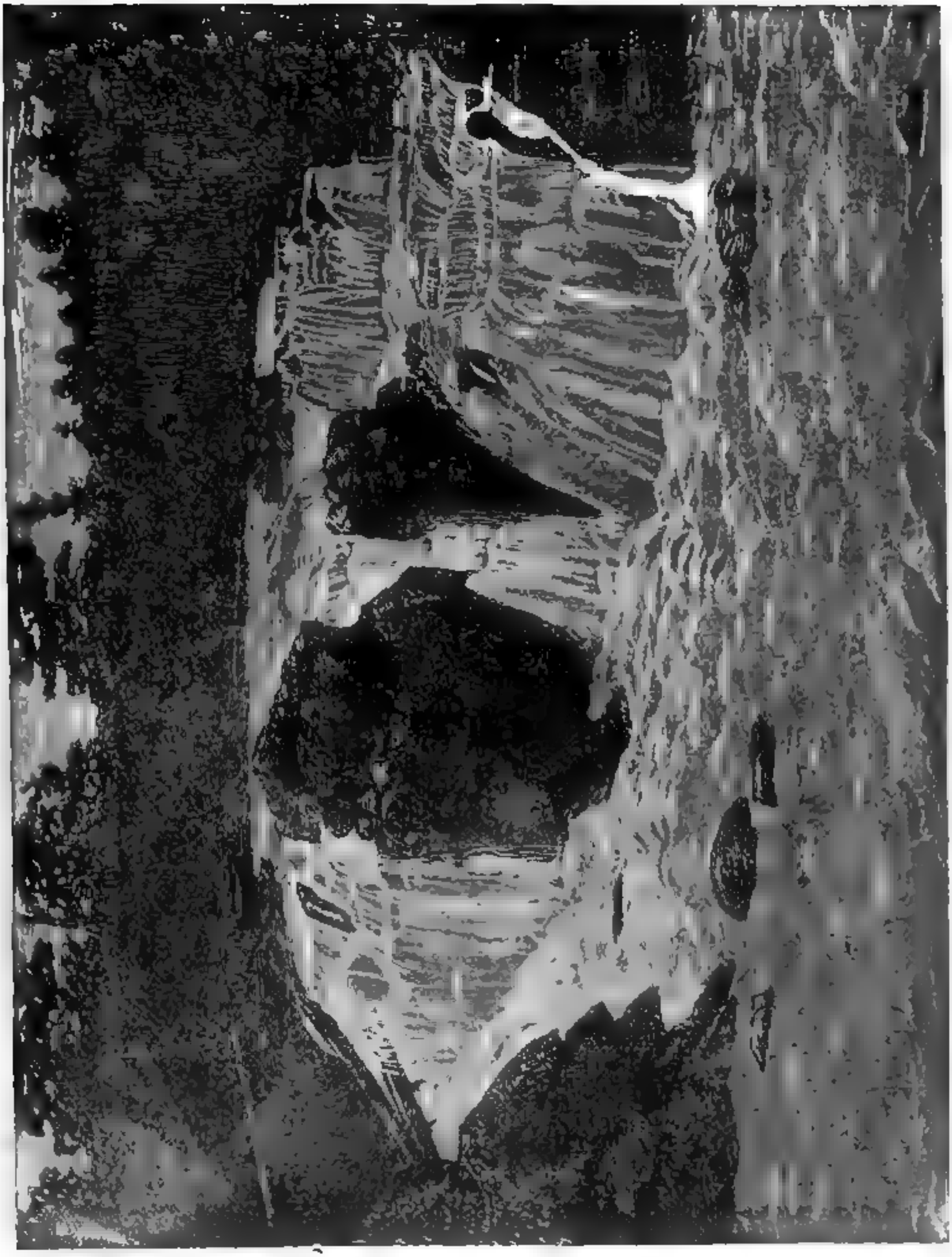
The larger island, in the east half of sec. 20, 62-15, consists of conglomerate, rising about 20 feet above the lake. The inclosures are of all sizes up to a foot in diameter. There is a vertical schistose structure running about east and west, in which all the rounded masses seem to have been compressed and elongated. Some of the included masses are banded black chert, eight to ten inches long.

The shore-line of the bay in the south part of sec. 20, 62-15, is chiefly occupied by boulders, but graywacke appears on the western side, nearly where the section line intersects the shore. Further west, on the point in the S. W. ¼ of sec. 20, 62-15, is seen a good exposure of bedded graywacke rising gently from the water-level, smoothly glaciated, but exhibiting the anomalous strike N. W. and S. E. The point, a little further from the water, rises to about fifteen feet. Thence to Hoodoo point the shore-line is formed by drift materials.

Some small islands in Vermilion lake. Kid island, which is in the S. E. ¼ of sec. 18, 62-15, rises about twenty-five feet above the lake. It consists of a slaty graywacke on the south side, and the felsitic rock seen on Ely island, on the north side.

The island in the S. E. ¼ of sec. 7, 62-15, has on the north side an exposure of "sericitic" schist, with abundant interlaminations of silica, or siliceous material, dipping 80° toward the north. The silica bands here, in their manner of distribution, resemble those that gradually encroach on the green schist at points noted north of Tower, where the fragmental jaspilyte fades out and gives place to the schist entirely. This rock forms the island.

Key island, which is situated in the southern part of sec. 11, 52-15, is underlain by graywacke rock, visible at the southwest and the eastern ends of the island, but the small islands south of the eastern extremity of Key island, in sec. 11, 62-15, are composed of the felsitic conglomerate the same that forms Ely island.



KAWASACHONG FALLS, KAWISHIWI RIVER, BIRCH LAKE AND RIVER AND DUNKA RIVER.

Kawasachong falls. This fine-water power is formed by the Kawishiwi* river near its entrance into Fall lake. It is represented by the accompanying sketch, which was drawn by Mrs. M. S. Mowry from a photograph made by the writer in August, 1886.

The rock here exposed was referred to in the report of 1880 (No. 356). It is an important and typical rock of the region, and seems to play a leading part, in towns further south and east, in producing some of the principal topographic features. It is represented by samples 997, 998 and 999. It is a green doleritic rock, more or less affected by decay, lies in heavy, irregular bedding that slopes northward at a greater angle than the descent of the river through the rapids from Garden lake to Fall lake. This bedding is variously blocked out by joints, and sometimes it shows a columnar structure. The beds are unconformable with some jaspilyte which appears on the right bank near the head of the rapids, and on the trail near the same place, apparently lying on the upturned vertical beds of the jaspilyte. This jaspilyte is more correctly styled a magnetic quartz-schist. It stands in sheets nearly vertical, yet dipping north. It is dark-colored, but sometimes is reddened with hematite. Sample No. 1000.

This heavily bedded, rough, refractory doleritic rock can be of no other than eruptive origin. It is supposed to be inferior to the principal gabbro masses of the Mesabi range, as will appear by further descriptions, and some phase of it forms the contact rock on other, nearly vertical, strata in nearly all places where the junction line can be seen. It extends southward indefinitely, giving some characteristic outcrops on Garden lake and in the eastern portions of Kawishiwi valley.

The geological situation at Kawasachong falls is expressed, in general, by the following diagram, which shows a section north and south through the falls:

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*The Grand Marais Indians apply the name *Kawasachong* to Fall lake, meaning mist or foam lake, referring to the spray and mist produced by these falls, visible to the canoe-man who coasts along the shore past the mouth of this river. This name and this spelling were obtained of the well-known Indian guide and trapper, Paul Morrison, by the writer in 1878 and, on account of some doubt of their correctness, they were again given by him to the writer in 1886.

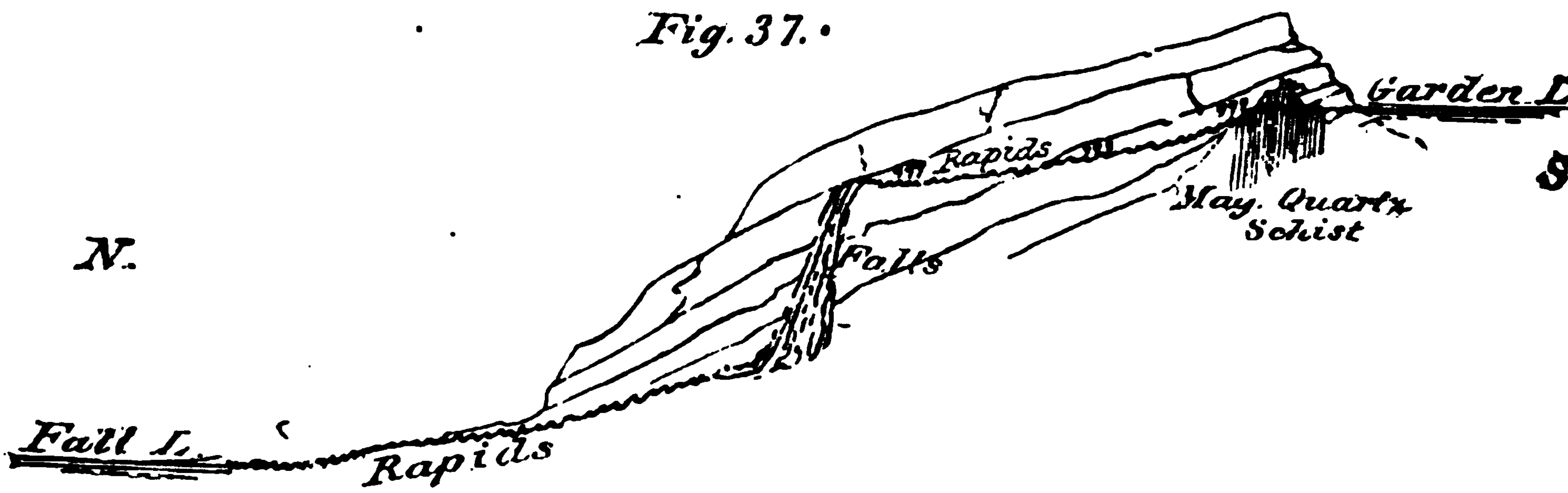

Fig. 37.—*Profile through Kawasachong falls, from Fall lake to Garden lake.*

The south shore of Fall lake. Westward from the mouth of the Kawishiwi river, the rock that forms the falls continues, forming rather high land, particularly in the point that projects into sec. 17, 63-11. It appears at the shore on the point in the N. E. cor. of sec. 19, 63-11, where the bluff rises about twenty feet.

Near the centre of sec. 19, 63-11, at the lake shore, is a confused "sericitic schist," near the water, coarsely fissile lenticularly, not soft, but with a jagged upper surface, represented by No. 1004. The prevailing structure in this, dips southerly. Above this rock, in the same bluff, is a rock represented by 1005, which is a doleritic rock, probably the representative of the Kawasachong falls rock. It has a coarse jointage, and an irreg-

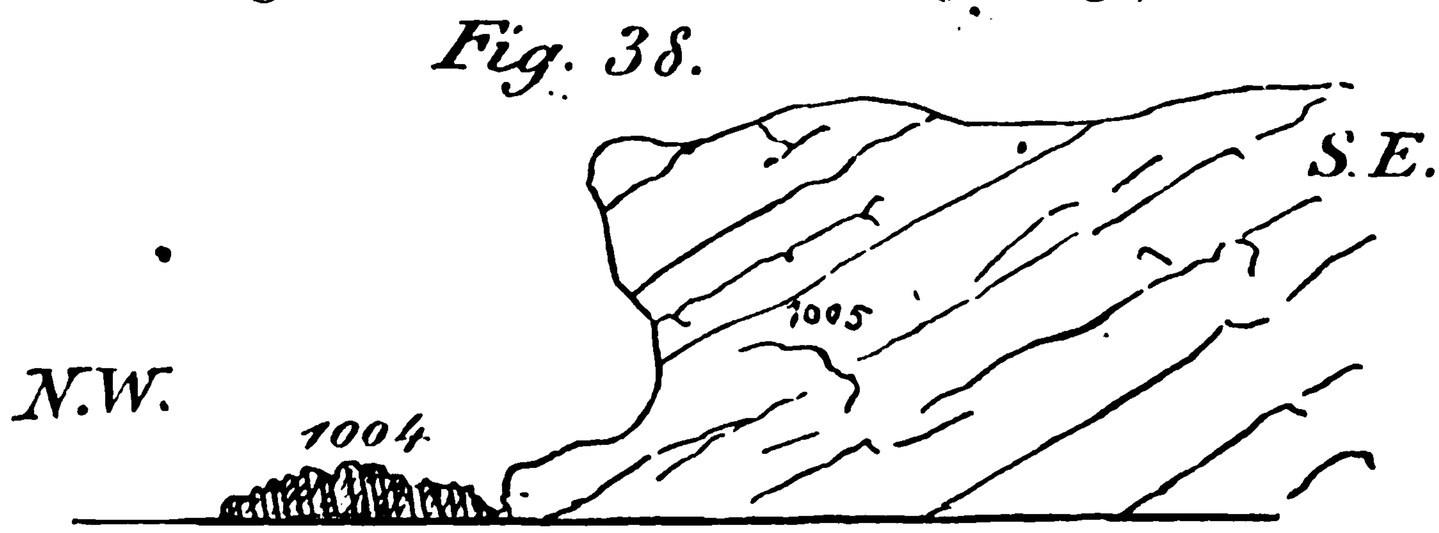

Fig. 38.—*Bluff west of Kawasachong falls, south shore of Fall lake.*

ular coarse bedding that dips about N. W. at an angle of 30° from the horizon. This can not be seen here to overlie, nor to pass into, the rock near the water (1004) but it is possible that the rock near the water is only a rotted and disintegrating condition of that in the upper part of the bluff. There is a greater difference in the outward prevalent structure than in the mineral composition.

At the sharp point projecting southwestward, a little further southwest, but near the centre of the same section, is an interesting exposure which seems to shed light on the nature and origin of the rock forming the Kawasachong falls. A rock which resembles the schist No. 1004 occupies the lake shore nearly all about, at the water level. But at, or near, the extremity of the point, on the north side, the rock which forms the falls of the Kawishiwi, and which seems to be continuous to this place in the uplands, appears in the form of a dike rising through those schists, the contact on the south side of the dike being plainly visible. One is crumpled schistose, fine-grained, hardened, the schistose structure running N. N. E., at an angle of about 75° from the horizon; and the other is coarsely jointed, the main jointage system being, as stated before, at an angle of about 30° from the horizon. The colors of the two approach the same tint of doleritic green, and the hardening action of the dike is perceptible for some distance on the schist. The sketch-map on next page (Fig. 39) shows the relative position of this dike, and the shape of the joint formed by it.

One of the interesting points about this exposure is the widening of the area of the eruptive rock toward the east, by means of overlie on the schists. This is inferred to have taken place at other places, notably on the jaspilyte near the head of the rapids from Garden lake, as shown by Fig. 37, but at no place has the actual contact and overlie been seen so boldly exhibited as at the place indicated on the map.

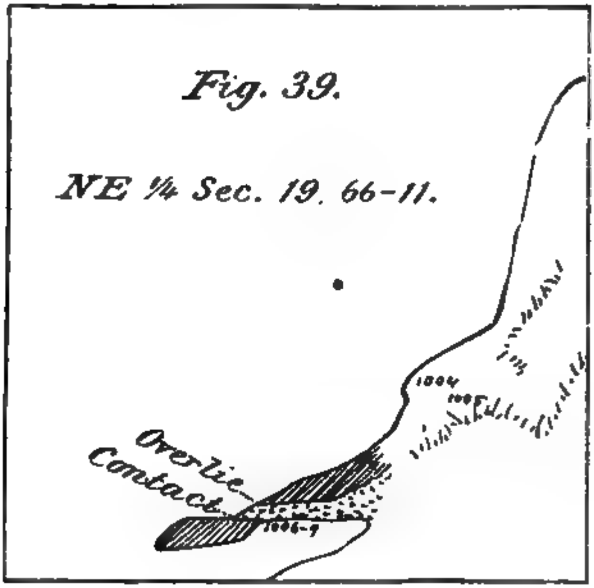

Fig. 39.—*Sketch-map of a point on the south shore of Fall lake.*

A cross-section of the point, showing this overlie, would be about as represented by Fig. 40, the observer looking about N. E. The line of contact, and of change of structure is not so abrupt as the figure indicates, the eruptive rock being welded on the schists, the schists becoming diabasic, and making a rock similar to that which is seen on the eastern branches of the

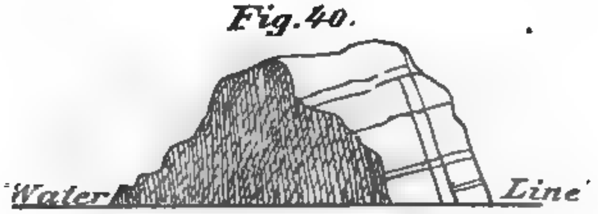

Fig. 40.—*Overflowing dike-rock lying on schist.*

Kawishiwi where the same conjunction of geological features is exhibited. The entire transition, excepting the general hardening of the schists, is completed within the space of an inch, or even less. Indeed on close inspection it is apparent that a mere film, or a line only, evident on the face of the bluff by a thread-like groove, separates the two rocks in many places.

No. 1006 represents the schist near the dike.

No. 1007, small specimen of granular quartz with pyrite disseminated, got in contact with 1006. There is very little of this. It is evidently due to the effect of the dike on the rock through which it comes.

1008. Obtained two feet from the dike, on the south side.

1009 is a sample of the dike-rock.

1010 represents the contact, containing some of each rock, at the place represented in Fig. 41. But this specimen does not fairly show the flowage structure in the diabase. It is difficult to get a specimen containing all the characters.

Parallel with the line of contact, in the diabase, the weather brings to light what might be styled properly a flowage structure, while the schistose structure is continued in the schists squarely up to the line of contact, the two systems of lining making an angle, at the contact line, of about 20 degrees as in Fig. 41.

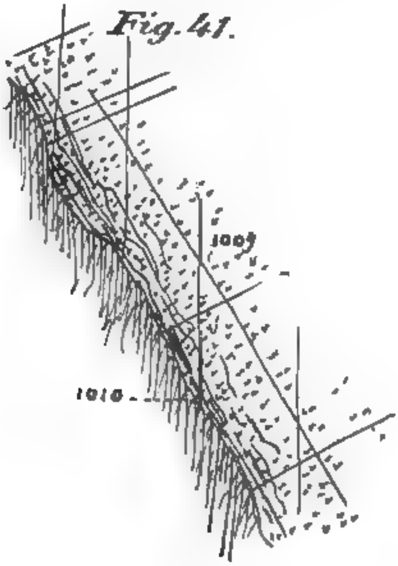

Fig. 41.—*Showing the line of contact of the dike-rock of Fig. 39 on the schists, and the flowage structure in the dike.*

The flowage structure in the diabase extends indistinctly sometimes about three inches from the line of contact. It is made visible on the weathered surface by the more rapid whitening of one of the constituent minerals (probably a triclinic) which

for some reason was disposed along the contact in somewhat greater abundance in thin parallel lines.

This is probably but one of the smaller outlets for the igneous rock seen at Kawasachong falls and further south and east. It forms a great stratum, lying unconformable on the schists here, apparently descending toward the valley of Fall lake. Whether it was contemporaneous with the trap-rock of the Cupriferous, remains to be seen by further investigation, likewise whether it is older or more recent than the gabbro rock of the Mesabi range.

A trail passes south from the bay in sec. 19, 63-11, to the head of the bay extending from Garden lake into sec. 30, 63-11. In the S. E. ¼ of sec. 19, is a hill, which is broad and heavily timbered, and at various places near the top are outcrops of jaspilyte, but whether they are transported masses from the main range further south, now embraced in the igneous matrix which forms the main rock of the hill, or are themselves a part of the rock *in situ*, could not be learned from any observations made. The jaspilyte is more nearly a black banded magnetited quartz schist. At one point some surface working has been done, but there is shown no dip or strike, simply a breccia of quartz-schist cemented by quartz veins. The rock of the hill on which this occurs is represented by No. 1011, which was seen at a number of places in small outcrops between the lake shore and the top of the hill. It is essentially the rock that forms the Kawasachong falls.

The quartz-schist last mentioned, containing veins of silica, is cemented in the form of a breccia. The quartz in these veins has the appearance of being "chalcedonic," like the quartz interleaved with the jaspilyte at Tower, and, on disintegrated angles projecting beyond the rest, it shows a similar granular structure. This may show that this was a breccia earlier than the deposition of this (supposed) sedimentary quartz, or that the white granular quartz at Tower is not sedimentary. Sample 1013 shows these veins of chalcedonic silica.

On the trail running south through sec. 19, 63-11, after passing an irregular elevation that seems to be made up of igneous rock, and then a low space, there intervenes another ridge made of a coarse greenish gray rock resembling a modified graywacke of a rather fine grain, No. 1014. This is but little south of the section line between 19 and 30, and to the west of the trail. It rises about fifty feet above the trail. This rock seems to vary toward

the rock that makes the falls of the Kawishiwi. But this variation is due probably to the action of that rock upon it when the two came into contact at the time of the eruption of the molten rock.

At the lake shore in the N. E. ¼ of sec. 30, 63-11, is rock No. 1015, which is identical in mineral character with the last. This is found where the trail from Fall lake reaches the bay in sec. 30, and shows its sedimentary origin more evidently than further north. It is fine-grained, brecciated, rising in a rough and coarsely jointed manner in hills about 50 or 60 feet above the lake, and extending in a series of short, overlapping ridges westward, rising a hundred or a hundred and fifty feet above Garden lake.

About throuhg the centre of sec. 30, 63-11, runs a series of ridges, showing more or less of jasper-hematite (1016). Their direction is ten degrees south of west. This range is on the south side of the hills mentioned (1015), and they show a crumpled and broken banding of iron and jasper, the latter being sometimes red, but never having, so far as seen, a persistent dip or strike. Several parties have located land for iron-mining in this section.

At one point, east of the centre of the section, the bands of jaspilyte have a direction N. 60° E. over quite a large area. It is associated with a greenish wackenitic rock which seems to be worthy of the name of porodyte in some places. This doubtful rock lies both on the north and on the south sides of the ore. It is not, however, apparently conglomeritic.

This ridge or series of ridges continues, with about the same hight, west into the next township, veering a little to the south, passing through the south part of sec. 25, 63-12, into secs. 35, 34 and 33, but the same kind of rock (1002 and 1003) widens out toward the north reaching as far as the shore of Long lake in sec. 28, 63-12, where it presents a rough and broken aspect. It is difficult, in the field to distinguish rock represented by 1002 and 1003 from 1014 and 1015, and still more difficult to distinguish it from 1004 and 1005. It is hardly sericitic; it is flinty or felsitic. It is in huge angular mass or blocks. These have a schistose direction, but no sedimentary banding is apparent. On the trail from the shore of Long lake, sec. 28, 63-12, to Patterson's trenches, S. E. ¼ sec. 28, 63-12, this rock forms a ridge that rises about seventy-five feet, similar to that mentioned in sec. 30, 63-11. The trend of the schistose structure, in sec. 28,

63-12, is apparently northeastward. It acquires silica in lenticular sheets, and in small nodules, as well as having it finely disseminated through the mass, somewhat in the manner of the green schists at Tower. It also becomes flinty, or finely felsitic, though all the time of an olive-green, or greenish-gray color. In some places it looks some like the well-known graywacke, of Vermilion lake, but it is not arenaceous like that, nor bedded in regular sheets. Its analogue at Vermilion lake, if it have any there, would be found in the porodyte in the north side of Stuntz island. It is not always brecciated, and in irregular angular masses, such as represented by 1002, but is sometimes inclined to be schistose, or perhaps slaty, as shown by No. 1003, got about midway between Long lake and Patterson's trenches.

About Garden lake. The island in sec. 20, 63-11, near the outlet of Garden lake, consists of the same rock as that at Kawasachong falls,—a green disabase, but has some of the schistose structure due to disintegration that is visible at the falls. But the greater part of it is entire, or massive. Similar rock extends along the shore of the lake southwest from this island, nearly to the bluff at the head of the bay in sec. 30 where it gives place to a changed graywacke (1014), as already noted. In one place, on the north side of this long arm, about in N. W. ¼ of sec. 29, 63-11, this is so much changed by, and mingled with, diabase that it does not differ much from the diabase. The most notable difference is in having a pinkish-red, weathered exterior, in some small areas, and in being porphyritic and quartzose in others. It has a streamed, or flowage structure in narrow belts that surround lenticular, structureless areas from six inches to twelve inches in diameter.

On the point on the south side of the lake, in the S. W. ¼ of sec. 21, 63-11, is black, or red, jaspilyte, so far as visible mainly in loose pieces, but so abundant that the bed-rock must be near. These are under water except at very low stage. The black, magnetited condition of this jaspilyte is less able to resist frost and weather, separating in curving and conchoidal sheets parallel with the bedding.

There will be some difficulty in separating by mapping, if not by obvious mineral characters, the changed graywacke seen about the west arm of this lake and elsewhere, from the diabase. I can not do it in the field with satisfaction. It will require a more careful study of the specimens collected. Still this belt of rock so indefinite is not very wide. It pertains to the contact

phenomena. There is a wide distinction apparent between the typical rocks, and sometimes these differences are brought into abrupt contrast by a sudden transition, but it is usually not so. The transition is usually gradual, the more enduring, noticeable distinction being a lighter green color, and a siliceous aspect in the wackenitic rock, i. e. an acidic character, and a dark-green or basic character in the diabase.

About on the section line, between secs. 21 and 28, 63-11, on the south side of the lake, just south of the little point at which appear the foregoing detached fragments of jaspilyte, is an exposure of green diabase over which one may walk, on a glaciated surface, for a distance of fifty or sixty rods. This is at the level of the lake, and is partly flooded when the water is high. Here can be read a very instructive lesson in metamorphism. There is a transition, under the varying influence of the lake at higher or lower levels, and the slight difference in crystalline texture at different places, on the same rock surface, from nearly a massive doleryte to a green chlorite schist. The gradations in structure, color and mineral character are indistinguishable from foot to foot over the surface, but the extremes, exhibited at the opposite ends of the uncovered rock-beach, are so great that one would hesitate, without such ocular demonstration, to admit that they are different conditions of the same rock. Perfect facility here is afforded for the inspection of every inch of this rock-surface. This is the doleryte (or diabase) that has been referred to as lying unconformably on the jaspilyte, and as constituting the rock at the falls of Kawasachong. It here changes to a green chlorite schist, and recalls at once the green schist seen to have the same relation to the jaspilyte at Tower. It almost demonstrates the eruptive origin of that green schist.

1017. Green schist with disseminated striated crystals of white calcite that rapidly effervesce in acid, and some granular (?) quartz, such as seen in the green schist at Tower, in small lenticular patches. From the foregoing outcrop N. W. ¼ of sec. 28, 63-11.

1018. Similar schist, from the same exposed surface but showing no white crystals; same place.

1019. Similar schist, less schistose; same place.

1020. Similar rock, hardly schistose; same place.

1021. Similar rock, but evidently changed from an igneous rock; same place.

1022. Changed doleryte; same place.

1023. From the midst of the very schistose parts (1017-1018) showing a preservation of firmness and massive structure in some places; from the same place.

The strike of the schistosity is E. 23½ degrees N. and vertical. There is no banding of sedimentary structure in this rock.

On an island about three-fourths of a mile further east, in the bed of the river, the strike of the schist is E. 15 degrees N. It here verges more evidently toward the Kawasachong falls rock.

At Quinn's, N. W. ¼ of sec. 27, 63-11, among the boulders of granite, etc., are some of jasper and hematite. The rock in outcrop is diabasic, apparently belonging to that last mentioned, though weathering rather light-colored, and in that respect resembling the modified graywacke.

At Julian Bausman's, S. W. ¼ sec. 23, 63-11, is a good showing of iron, though visible in several isolated outcrops, and at no place in large amounts. It is not worked yet, nor uncovered. It is probably in the range of that noted in the S. W. ¼ of sec. 21, 63-11, and appears like it. Mr. Bausman says it is traceable, by needle mainly, being magnetic and rather black-red, through the rest of this section and eastward. Rock No. 1024, obtained at Bausman's, S. W. ¼ of sec. 23, 63-11, is a somewhat schistose magnetic iron ore. This does not show the usual character of the ore here, so far as can be seen, but one of the forms it takes.

This sample gives:

Iron	47.07 p. c.
Titanium	traces.
Chromium	none.

In sec. 21, 63-11, according to Mr. E. Byrne, a ridge of black jasper and magnetite, or two of them in one place, extends from near the east side of the section nearly due west, becoming involved with, or "covered by," at least replaced by, a quartzose poroditic rock, No. 1 (H) and No. 283 (W). After an interval of about 150 feet of this rock, the same black rock recurs, and extends westwardly. It is next seen further south, where it constitutes a distinct ridge, and is traceable through two-thirds of sec. 21. This iron ore is represented by No. 1025. This iron range seems to continue, with more or less interruption, through secs. 23 and 13 in 63-11, and appears also in the next town east.

On the N. W. ¼ of sec 28, 63-11, a diabasic green rock (949) cuts a greenish, hard, finely schistose rock (948), the contact being well exposed on the south side for a distance of a few feet. A schist somewhat resembling this, but more nodular, and more like an igneous breccia of schist and diabase, forms a small island in the S. E. ¼ of sec. 20, 63-11. It dips south, but stands nearly perpendicular.

At the lower end of the rapids which are formed where White Iron lake descends to Garden lake, N. E. ¼ of sec. 32, 63-11, are two short, small tunnels, running in opposite directions, into a siliceous schist or bedded quartzyte, which disturbs the compass needle by magnetic attraction. It dips N. N. E. 80°-85°. It is somewhat brecciated, and recemented by chemical silica and pyrites. In some places this bedded quartzyte is black, and in others blue, sonorous and brittle, recalling the Animikie quartzytes. It is represented by 950. The quartz in which the tunnels were excavated is represented by No. 951. This locality is known locally as *Silver City*, so named by the proprietor of the tunneling.

At the upper end of the rapids which run north from White Iron lake, the rock is micaceous magnetic quartz-schist, dark colored, becoming greenish. On the west side, near the level of White Iron lake, a dike of greenstone cuts these schists, running about east and west, the contact being plainly visible, the change of the rock being abrupt. In some large loose pieces of the magnetic schist, lying near the dike, it is seen to become garnetiferous, and also has pyrites cubes. The beds here stand nearly vertical.

In the northern part of sec. 32, 63-11, on the west shore, the diabase schist is igneous, resembling much that can be seen in the Cupriferous.

Notes on White Iron lake. The syenite along the west side of White Iron lake, in sec. 6, 62-11, is represented by No. 952, which is coarse, weathers red, appears like an eruptive rock, has contact with a changed "gabbro" on the east side of the lake (about centre of sec. 12, 62-12) and extends south. The trail which passes eastward from White Iron lake to the river in sec. 19, 62-11, passes over immense and numerous boulders, most of them being of coarsely crystalline syenite, the feldspar being porphyritically distributed (953). The river evidently sometimes floods much of this trail, and keeps the stones free from soil and vegetation. This rock is in place near the east end of

the trail, and at the river bank, and extends northward causing the foaming rapids through the N. W. ¼ of sec. 19. It is everywhere homogeneous and massive. Several islands in White Iron lake, in the north part of sec. 24, 62-12, are made apparently of this rock.

As to the age of the syenite about White Iron lake, compared with that which is associated and interstratified with the mica schist, seen on the northern side of Vermilion lake, there is, at present, no certain datum on which to base an opinion. Its genetic relations have not (now) been made out, and its geographic position and stratigraphic associations are the only guides. It is disconnected from the other area by lying further south, separated from that by a belt of greenstone, quartzytes, schists, argillytes and mica schists. Its associations are not very different. Veins or dikes of it are seen running through the doleryte along the west side of White Iron lake, in a manner analogous to those seen in the hornblendic-mica-schist series on the north shore of Vermilion lake. By Dr. Wadsworth, as described below, it cuts mica-schist and quartzyte near the northern limit of its area, at the north end of White Iron lake, on sec. 32, 63-11. The east shore of White Iron lake was examined by Dr. Wadsworth from the foot of the lake to the southern extremity, and his notes are given below.

Dr. Wadsworth's notes on the east shore of White Iron lake:

The island in this lake lying in sec. 33, 63-11, and in sec. 5, 62-11, is granite. However, no solid granite could be found in place, but the fragmental portions had evidently been formed by the breaking up of a granitic mass, and they were in place or nearly so (1110).

At the foot of the lake or its northern end the rock is a schist which can be styled, owing to its varying composition, in different portions quartz, hornblende or mica-schist, etc. This rock stands nearly vertical or with a slight dip from the vertical towards the north. The strike is southerly or to the east of south. In places the schist is ferruginous, the ore being principally magnetite. Although this schistose formation is sedimentary and unlike the lake Superior iron ore formation, yet it will doubtless be compared by most geologists with the latter, as it in places shows similar bandings and contortions. Yet in my judgment the two formations are utterly unlike. This schist has evidently been altered by a hornblendic granite which has been intruded through it; which intrusive rock is doubtless the cause of the induration and contortion of the schist and for its ferruginous material becoming magnetite.

Nos. 1111, 1112, 1113, 1114 and 1115 represent different forms of the same schist, while No. 1116 is the granite at some distance from its contact with the schist, and is the same as the granite of the island (No. 1110) and elsewhere about the lake.

Nos. 1117, 1118, 1119, 1120, 1121 and 1122 are junction specimens of the granite and its contact with the schist. Nos. 1123 and 1124 are portions of the schist which have been more indurated and altered by contact with the granite. These specimens were taken low down on a cliff, while all the other contact specimens were taken higher up on the hillside except 1122. As the contact line was followed up the hill the schist is found to be less indurated. No. 1125 is a portion near the lower contact (1123) which still shows the schist banding and it is cut by two granitic veins.

No. 1126 is a portion of the edge of the granite at the contact, which is filled with fragments of schist. The schist extends southwardly on the lake shore, with some intermingled granite intruded through it, for about half a mile.

It is quite difficult to ascertain the strike by the compass owing to the magnetite in the schists. No. 1127 is a specimen of the contorted schist with magnetite. On a point marked on the map occurs the gabbro (No. 1128) cut by the intrusive granite (1129).

No. 1130 is the contact of a dike of this granite, with the gabbro through which it is intruded. No. 1131 also shows contacts of the granite and gabbro. The gabbro mass follows the lake shore on a bay and trends southerly or to the east of south. It is coarsely crystalline, much altered and micaceous, and would be called by name a minette. Fragments of the gabbro are inclosed in the granite.

On the "meander" line between secs. 6 and 7, 62-11, granite *in situ* occurs extending both north and south of that line. South of the line a little black hornblendic gneiss (No. 1132) was observed cut through and through by the granite. This granite extends in a ridge running west of south (40°) into the interior. All the granite is cut by dikes of micro-granite (1133).

Some micaceous gabbro* (1134) is seen on the lake shore in sec. 12, 62-12. This gabbro is cut through and through by the granite. The rest of the east shore of the lake to the point where the main stream enters from Birch lake is granite, and most of the way the rock is in place. In some places the granite is cut by a dark hornblendic rock (No. 1135) in irregular but small dikes. The granite closely resembles the so-called Laurentian gneiss. It shows banding or foliation and contains fragments of schist. The banding is here regarded as a foliation caused by fluidal structure; while others think it to have been produced by sedimentation.

On the ridge between the lake and its inlet numerous boulders of altered gabbro (dioryte) were observed cut by dikes of granite.

Birch river and Birch lake. The further notes of Dr. Wadsworth, on Birch river and lake, are as follows:

Following up the river from White Iron lake toward Birch lake granite in place or in boulders was observed to extend all the way to the line between sec. 31, 62-11, and sec. 6, 61-11. At this point the granite is in place, and it was found to extend on the west side for about half a mile into the unsurveyed

* The rock which Dr. Wadsworth here styles gabbro is a part of the mica-hornblende-schist series. It may have been originally a gabbro, but it is not connected with the great gabbro overflow which is uniformly meant when gabbro is spoken of elsewhere in this report, but must have been of much earlier date. It is that which, at the west end of Birch lake, is noted as varying from hornblende schist to mica-schist, and is there in the same way cut by dikes of "granite."

T. 61. Here gabbro (1136) appears. This is much less altered than the preceding gabbro observed, and it bears much well-marked feldspar. From this point the gabbro extends all the way on the west side of the lake until the lake passes out of T. 61-11 into 61-12 at the secs. 30 and 25. A short distance to the west of meander stakes between secs. 24 and 25, 61-12, the gabbro becomes fine-grained and appears as if it ended as a fine-grained diabasic looking rock, (1137).

Just beyond this are seen fragments of a peculiar rock resembling an indurated sandstone or schist, and containing much magnetite (1138).

To the east of the meander corner, between secs. 23 and 24, the granite was found in place. This, like much of the granite previously observed, contains porphyritic crystals of red feldspar. No. 1139 was found in place just west of the same corner.

Here some boulders of schist cut by granite were seen.

About ½ of a mile west of the corner above given, the granite was again found in place and is of a fine-grained texture like a micro-granite (1140). The concentric jointing shows excellently well in places.

On the east side of Birch lake, about N. W. ¼ of sec. 20, 61-11, is a perpendicular bluff of coarse gabbro rising about 32 feet above the lake, having large rhomboidal fallen masses lying at the foot. It faces west, and shows on the perpendicular wall a coarse-bedded structure, brought out by the grooves that run across the wall produced by unequal weathering. These dip toward the south, at an angle of forty degrees from the horizon, the large grooves being from three to five feet apart, but sometimes having more frequent finer ones between them. The following sketch (Fig. 42) illustrates this bluff, in a rough way. The grooves are very regular, but some of them fade out in passing along.

Fig. 42.

Fig. 42.—*Bedded gabbro bluff, east side of Birch lake.*

These grooves are due to the weathering out of a mineral which happens to have been more abundant in these lines, compared to the other minerals, than in the rest of the rock. This same mineral is found throughout the rest of the rock, though not arranged in gneissic order, and its more rapid disintegration causes numerous small pits over the weathered surface. On

inspection this mineral appears to be olivine; the rock also contains black mica, in amount greater than customary for gabbro. Rock 954 represents this gabbro.

At about the section line between secs. 29 and 30, 61-11, on the south shore, is another perpendicular bluff of gabbro. Indeed numerous nearly perpendicular bluffs, from 30 to 50 feet high, made of this rock, appear at the shore through sec. 30, while on the north shore they are gradually ascending from the water level. This is owing to the prevalent dip of main structural planes of the gabbro being toward the south, or southeasterly.

A curious fact is the quick change in the character of the boulders, as the character of the underlying rock changes. In the syenite region they are mainly of syenite, but where the gabbro begins they immediately become almost wholly of gabbro. The decaying olivine gives a pitted surface to nearly all of the boulders.

Some of the syenite (or granite) seen in boulders in sec. 26, 61-12, has the appearance of gneissic structure, suggesting that part of it may have been derived from metamorphism of sedimentary rocks (955). It is dark-colored, the crystals are imperfectly formed, and crowded, and much finer than in the syenite mentioned seen at White Iron lake. Other parts (seen in boulders in sec. 26) are chloritic and dark-colored (956), and some slabs appear like a micaceous quartzyte, but may be a somewhat changed olivine rock (957).

The little point on the north shore, situated in the N. E. ¼ of the S. E. ¼ of sec. 21, 61-12, consisting of a breccia of mica-schist cemented by granite No. 958, shows the manner of contact. The granite goes generally in all directions, embracing the mica-schist, and also appears as isolated masses. It also runs parallel to the schistose structure, producing a bedded gneiss, which dips about west 75° from the horizon. This is the same as the mica-schist and interbedded granite seen on the north side of Vermilion lake. 958 A, shows some of this mica-schist, while 958 B, shows the nature of a narrow vein or "dike" of the granite, and the full width of it (about ¼ inch), beyond which it continues but gradually diminishes to a needle point, and vanishes in the schist. It is hard to understand how a true igneous dike could thus fade out. It seems to disappear because the mica gradually prevails over the other minerals and converts it into mica-schist, which itself seems to contain only the minerals seen in the granite.

Through the western part of sec. 22, 61-12, on the north shore, only the igneous looking, coarse-jointed syenite can be seen. It is coarsely crystalline, has a bedding structure similar to what can be seen in the trap-rocks of lake Superior, but in the eastern part of the section a fine-grained, red-weathering bedded granite appears, both near the shore and also in a bluff at some rods from the shore. The bluff that faces the lake has the appearance of being an old wall of masonry, the rough, thin layering appearing about as distinct as the courses in a rubble wall when pointed with mortar by the mason and smoothed by the trowel. The beds are from four to eight inches thick, and dip easterly about 5° from the horizon. This granite, which is fine-grained and micaceous, extends eastward from the S. E. ¼ of sec. 22, 61-12, and is represented by 959. The figure herewith (Fig. 43) shows three successive outcrops of granite. *A* occurs on the point in sec. 21, already mentioned. *B* is about three-quarters of a mile further east, and *C* is on the S. E. ¼ of sec. 22. There are three different types. It is yet to be ascertained whether their genesis is the same. Rock 961 shows the contact between the coarse syenite like 953, as it occurs near the S. W. corner of sec. 24, 61-12, and the granite 955 and 959.

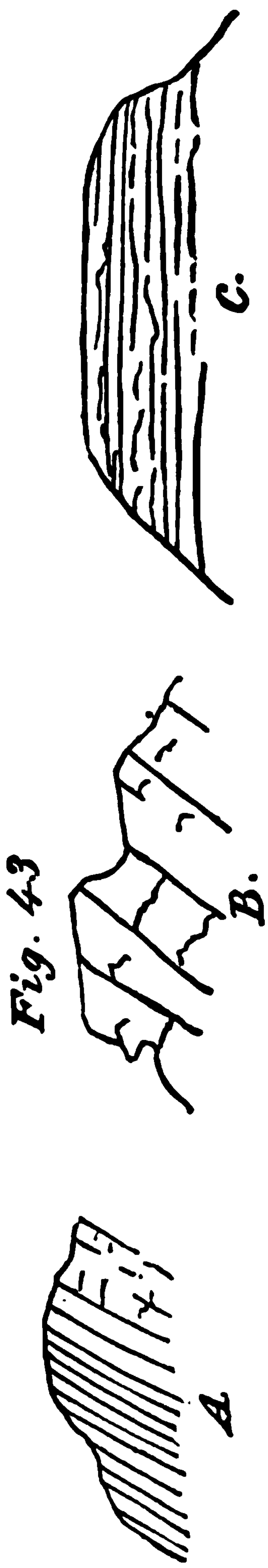

Fig. 43.—*Showing three types of syenite.*

Sometimes, in the porphyritic syenite, are bands of fine-grained syenite, running like dikes. Sometimes bands of coarse granite, or granulyte (i. e. orthoclase and quartz) run in the same manner. These last may be of chemical origin.

The relations of these different kinds of syenite, and of granite, are expressed by Fig. 44 which was sketched from the bluff at the S. E. ¼ of sec. 22, 61-12.

Rock 964 shows a coarse syenite, lying on 965, apparently conformably, 964 A is from a vein (or dike) of fine granular granite, six inches wide, running across the bedding of 964 and blending with 965. 964 B is mica-schist, a condition of 964 A, in small patches.

In 964 A is a central band of orthoclase and quartz, about half an inch wide, running parallel with the sides and fading out in about four feet.

Rock 965 is fine-grained granite, in bedded regular dip E 30°. 965 A is from a vein (or dike) of coarse syenite running zigzag in 965.

Rock 966 is the lower coarse syenite. This rises toward the left so as to appear to have been uncónformable under 965.

It might be presumed that the massive rock (966 and 964) wherever it occurs in this country is igneous, and 965 is of sedimentary origin. The above figure, however, with the veins that run from 965 to 964, and similar veins seen in the coarse syenite in numerous other places, seem to indicate that these rocks have a common origin. The fact that 965 becomes gneissic with mica, and alternates with mica-schist, thus apparently paralleling the granite in the N. W. part of Vermilion lake, indicates that this syenite and granite are on the same (Laurentian) horizon as that. What relation this has to the granite seen cutting the doleryte on the west side of White Iron lake is uncertain, but on the north shore of Birch lake the facts, so far as seen, indicate that the gabbro lies on the granite.

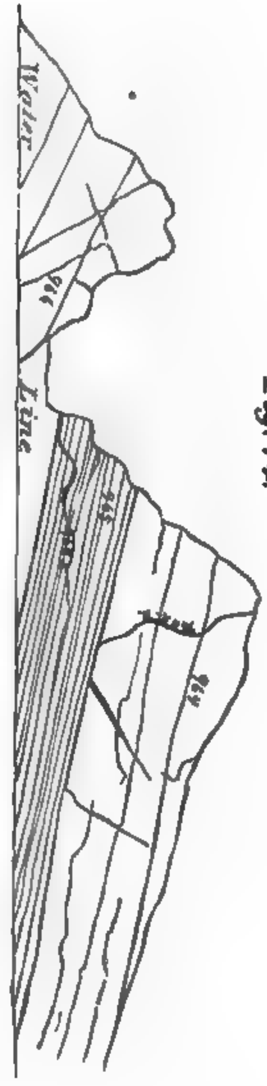

Fig. 44.—*Superposition in syenite masses.*

Fig. 44.

On the S. W. ¼ of sec. 24, 61-12, about a quarter of a mile east of the line dividing the syenite from the gabbro, is a low ridge, about fifteen rods from the shore, composed of a ferruginous olivine rock which is magnetic, and really constitutes an olivinitic iron ore (960). The rock appears under the moss and trees in irregular loose pieces, evidently in

place. The iron in this ore gave (when the fine-grained portions were analyzed by themselves) 54.1 per cent. It contains no titanium and no chromium. When the coarser crystalline parts were examined by themselves the iron amounted to 51.30 per cent, without titanium and chromium. This rock is the same as No. 1138, which was obtained from the same place by Dr. Wadsworth. Large boulders of the same ore are on the beach near this place.

At another point on the beach, about a quarter of a mile further west, is a small exposure of olivinitic gabbro, the rock being dark-colored, the augite being changed apparently to a large extent to mica, and the olivine being rusty. Very near this place, but lying to the west of it, and indeed almost in contact with it, is a large mass of fine-grained granite and such stone makes the boulders of the beach. This must be very near the contact line, as these large pieces form almost a continuous rock surface, broken only by opened jointage and covered somewhat by smaller blocks.

The point at the section line between secs. 23 and 24, 61-12, on the north side of Birch lake, is made of porphyritic syenite, like No. 953, but a little east of the point a few rods back in the woods, is a small ridge of fine-grained red syenite, resembling the "red rock" back of Grand Marais. It is represented by No. 963, and it lies in a position similar to that of the fine-grained rock 959.

Mr. Grant examined the bay in secs. 21 and 16, 61-12. He found on the north side of sec. 21 the rock 967, in the form of a vein (or dike) cutting coarse syenite. It is evidently a decayed or changed syenite, some of the hornblende having been replaced by an epidote-like mineral and some changed to a greenish-silvery, foliated, chlorite-like mineral, by far the greater part being rather coarse, pinkish orthoclase. At another point, north of the section line, on the west side of the bay, he met with a coarse syenite cut by a two-inch vein of fine syenite. This coarse syenite shows the hornblende is passing to mica. (See sample No. 918.) In other places has been noticed a mingling of black mica with hornblende in the coarse syenite. Sometimes, also, in the gabbro the olivine is embraced in the central part of the augite crystals. No. 968 represents the rock mentioned above where hornblende is so associated with black mica that it seems to pass into it, the rock being cut by a two-inch vein, or band, of much lighter-colored, or reddish, fine syenite. Both rocks are very quartzose.

An isolated rock, in place though, stands up in the water, in the bay, in the S. W. ¼ of sec. 28, 61-12, exactly like the mixed mica-schist and granite described on the point in the N. E. ¼ of the S. E. ¼ of sec. 21, 61-12. It here dips N. N. W. 75°-80°.

A dark dike, eighteen inches wide, runs N. E. and shows on the face of the coarse syenite, descending to the water, in the S. E. ¼ of sec. 29, 61-12. Sample 969 is so taken that it shows the contact with a thin transverse vein, that crosses this doleritic dike, of feldspathic rock which seems to have been deposited chemically in a fissure in the dike; as it is not connected with the adjoining syenite. The following figure shows this. (Fig. 45.)

Fig. 45.

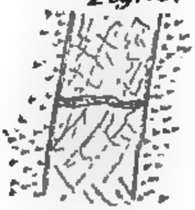

Fig. 45.—*Feldspathic vein crossing doleryte.*

This dike, which consists almost wholly of hornblende where sketched above, changes gradually to mica-schist (970). No. 971 shows its contact with the wall of syenite, the dike here being changed entirely to mica-schist.

This change in this dike seems to indicate that other local appearances of mica schist in this syenite, such as that seen on the point in the S. E. ¼ of sec. 21, 61-12, may be ascribed to the changed condition of an igneous rock, such as this undoubtedly was. In this mica-schist, thus changed from some igneous rock, there is a superabundance of mica, and the white ingredient is not certainly quartz.

At a point a little further north from this dike, on the same section, is a promontory of gneiss, the rock being striped with the gneissic structure, the striping dipping south 85°, but being somewhat contorted. Some of this rock is fine-grained, hard quartzose, granite, and in it occasionally are nodules of mica-schist, resembling the rock 970. This gneiss is represented by No. 972.

This gneiss continues westward to the town-line between 61-12

and 61-13, but is rather less distinctly banded, or bedded, than a typical gneiss, and instead coarsely fibrous in a direction coincident with the supposed prevalent dip, the coarse bars or contorted sheets, whichever they may be styled, showing a striation, or schistose structure seen from different directions, and sometimes manifesting the same illusory dip as seen in the dark gneiss or mica schist, mentioned in the N. W. part of Vermilion lake. As a gneiss it is very irregular. It is more correctly an irregular alternating of two rocks than a gneissic arrangement of minerals, though the latter structure can also be seen in some large patches. The rocks so alternating are syenite, fine syenite, fine granite, micaceous granite, and mica schist.

On careful examination over contiguous and continuous surfaces, the mica in this rock can be seen to be replaced by hornblende, and then it becomes dark, firm and dioryte-looking, but still twisted and contorted with a light-weathering syenite, and often mingled with a true granite of fine grain. In short, there seems to be a transition from mica-schist, as before surmised, to hornblende schist, this change taking place according to the less or greater exposure and disintegrating action of the elements. (Compare 1134.)

The manner in which this dark rock incloses parts of the lighter rock will allow of its being originally an igneous rock. On the other hand, the manner in which the syenite acts, with respect to the mica-schist, seems also to allow of its having been an eruptive rock.

No. 973 shows this rock in its hornblendic aspects. These (two) specimens were obtained from near contact with white-weathering, fine-grained, mica-granite, or gneiss, the latter being in strings, blocks and masses of all positions and shapes.

No. 974 shows this rock undergoing a change toward mica-schist.

If this mica-schist be a changed igneous rock, it should contain, theoretically, no original free quartz, and thus perhaps, as well as by some other characters which may be discoverable, it may be distinguished from the bedded sedimentary mica schist such as in the N. W. part of Vermilion lake passes into granite conformably.

Where Birch river enters Birch lake, in sec. 25, 61-13, the outcropping rock on the north side of the river is syenite and gneiss, dipping N. E., while through secs. 19, 20 and 29, 61-12 the dip is almost invariably in a southerly direction S. or S. S.E.

varying from 45° to 80°, further south, also, in secs. 25 and 36, 61-13, the dip is about south, and the rock, nearly everywhere that it is visible, is the same gneiss. But in the southwest end of the lake the rock is more hid by drift, and the shore-line consists of boulders and sand. A broad bay in sec. 36, 61-13. has a wide sandy beach.

This mottled schist is again represented by 975 (two samples) got at the extreme west end of Birch lake, near the head of the bay south of the mouth of the river. The samples are dark-colored, but the face of the bluff from which they came, sometimes about half of it, is light-colored. The rock seems to have been in some places originally a fine-grained dioryte, the feldspar not being individualized, but in others to have been fissured and the fissures filled with chemically deposited quartz and orthoclase.

The round point in the N. W. part of sec. 31, 61-12, is made up of a syenite which in some places shows the same gnessic structure, the latter being in narrow bands dipping south and in isolated included pieces. These patches are micaceo-hornblendic. This structure seems to gradually become less and less common in this direction (i. e. easterly), and to be most prevalent in the N. W. part of the lake.

The syenite in the N. E. ¼ of sec. 31, 61-12, is massive but embraces lenticular, elongated and irregular masses of fine-grained quartzose reddish granite, and the same also in veins. I notice that the hornblende grains have their elongation in the direction of the hitherto prevalent strike, producing a kind of structural arrangement that can be compared to that of gneiss.

There is an accumulation of fine, black, feebly magnetic sand on the beech at the S. W. ¼ of sec. 33, 61-12, near the mouth of a little rivulet. This probably is derived from the disintegration of some olivinitic iron ore at a short distance from the beach, similar to that seen on the north side of the lake (960). This sand, on analysis, gave the following result:

Silica	5.19
Metallic iron	41.12
Titanium dioxide	36.77
Alumina	2.95
Lime	trace.
Magnesia	35
Phosphorus	none.

Drift deposits cover the rock from this point northeastward

to the S. E. ¼ of sec. 28, 61-12, where the rock 978 outcrops conspicuously on the shore. It is a coarse, dark-colored dioryte, but shows the hornblende changing to mica, the mica scales originating within the hornblendes transverse to the fibrous grain of the hornblende. A short distance to the south of this the rock is gneiss, though on the north side, near it, but disconnected, is a similar outcrop of coarse syenite. Some of the last weathers red, and some light-gray. At the next point, north, is a still more conspicuous exposure of coarse syenite veined by finer red syenite.

Dunka river. At the mouth of this river the beach is one of sand, having a reddish aspect resembling that of the red beach at the mouth of the Brulé river east of Grand Marais. This color is also due to the same cause—the distribution of a red stone by the lake, and through the action of the river. Further, it is the same red stone—the "red rock" of the Cupriferous—which is here in pebbles not larger than an inch, and generally less than half an inch, in diameter, mingled with some of the same sizes, of granite and syenite.

There is a drift plateau bordering the lake along here, for a mile or two and ascending the Dunka valley, rising from 75 to 100 feet above the lake, making a fine expanse of farming land, now covered by a forest of mixed pine and deciduous trees.

The drift is, so far as can be seen, fine and clayey, and furnishes the beach with its materials. It dates back to the glacial age. It shows, by its composition, a northward transportation down the Dunka valley, and an extension of this movement from a point far enough south to bring rocks of the Cupriferous to the shores of Birch lake.

The river can be ascended by a canoe about half a mile, although there is a copious delta accumulation at the mouth, consisting of sand, which extends far into the lake, producing so shallow water that a small bark canoe drags on the bottom when carrying two men. The Indian winter trail, which leads to Beaver bay on lake Superior, leaves the right bank of the river near the town-line between 61-12 and 60-12, and it can easily be followed as far as we went, and probably all the way to lake Superior. It is obstructed by numerous old pines and poplars thrown down by the wind. It crosses the river in S. W. ¼ sec. 10, 60-12, and again in sec. 15, next south, and then bears more easterly. The country through which it passes is chiefly drift covered, and holds considerable good pine, though chiefly Nor-

way averaging 16 to 20 inches in diameter. Ten years' growth will make it very valuable.

After passing the main drift ridge, which rises by aneroid, 120 feet above Birch lake and ceases in N. W. ¼ sec. 10, 60-12, there succeeds a series of piles and ridges of granitic boulders, the syenite appearing *in situ* about on the half-section line in sec. 10, where the trail crosses it. At a point a little further north appeared numerous ferruginous olivinitic iron boulders (976). These are so numerous that it is evident that the low ridge on which they occur must contain a deposit of iron of this kind. These boulders show on analysis no titanium. At the crossing in sec. 10, where the river is 110 feet above Birch lake, the right bank is of drift, and rises forty or fifty feet above the river, the flood-plain being about five feet above the low-water stage. The water runs on fine grained olivine-bearing gabbro rock (977) or "muscovado," containing biotite, and descends rapidly below the crossing. The prominent high ridge which is visible from the lake, rising several hundred feet higher, crossing S. E. ¼ of sec. 7, the whole of sec. 8, and ceasing in sec. 9, 60-12, does not reach the Dunka river, but seems to be reduced to the low syenite ridge which appears in the trail N. W. ¼ of the S. W. ¼ of sec. 10. The gabbro seems to lie to the south of this ridge, a small hill of it rising on the west side of the river not far from the crossing.

It was much to our regret that the rainy weather, and the limited time at our command, prohibited a visit to the great ridge in sec. 8, 60-12. From other information, however, this is supposed to consist of syenite, and to constitute the eastern end of the range which is known further west by the name of Grant's range.*

East branch of Birch river. Kawishiwi river, in coming from the east, through towns 63-9 and 10, divides in sec. 26, 63-10, into two parts, the principal amount continuing westwardly through 63-10 and reaching Farm lake, and the other portion flowing southwestwardly through 62-10 and 62-11, uniting with Birch lake in sec. 6, 61-11. This latter portion, with that water which comes from lake Isabella in 62-8, through Bald Eagle and Gabbro lakes, is here included under the name East branch of Birch river. It will be seen that by the aid of Birch river and White Iron lake on the west, Farm lake and Kawishiwi river on the north, this river forms the hypothenuse of triangular

* The station "Messaba Heights," on the Duluth & Iron Range R. R., is on this ridge.

island—an island which seems to be constituted entirely of syenitic rock.

All the way from Birch lake, in sec. 6, 61-11, to the rapids in N. E. ¼ of sec. 27, 62-11, this river covers the line of contact between the gabbro and the syenite, indicating the existence there, for some reason, of a more erosible rock. At these rapids the water channel jogs suddenly to the north, though there is an extension of the bay northeastwardly in the probable direction of this contact horizon from sec. 27 into sec. 26. This is hypothetically the horizon of the ferriferous olivine rock. Further northeast, in secs. 23, 24 and 13, 62-11, this stream lies on syenite, and expands into Copeland's lake in the north part of sec. 24. In this stream rapids occur at the N. E. ¼ sec. 27, 62-11, ascending 16 feet; S. E. ¼ of sec. 22, 62-11, ascending 3 feet; S. W. ¼ of sec. 23, 62-11, ascending 5 feet; in the north part of sec. 23, 62-11, ascending 5 feet; in the N. E. ¼ of the S. W. ¼ of sec. 24, ascending 5 feet, and at the foot of Copeland's lake ascending 6 feet. Syenite prevails all the way up this water-course, through the whole length of Copeland's lake. It is generally coarse-grained and even phorphyritic with orthoclase crystals ½ inch across, sometimes these reaching 1½ inches across. But a fine-grained syenite is distributed through this rock very capriciously. It occurs not only in beds but in dikes and veins.

At the north end of Copeland's lake a change takes place. There is a dike running apparently N. N. W. from the little bay in the N. E. corner of sec. 7, across the river, probably being the chief agent in determining the location of the rapids at the head of Copeland's lake. It cuts through syenite. On the east side of this is much confusion in the character of the rock. Sometimes it is gneissic syenite, not porphyritic. Sometimes it appears to be diabase in limited areas, and sometimes apparently a dioryte, and again a fine-grained syenite, and a distinct gneiss, the last having a dip N. W. about 80°. On the west shore, running from sec. 6 to sec. 5, 62-10, is a bold and conspicuous, perpendicular wall of fine-grained syenite, but it has a frequent jointage like some igneous rock. A little further east, near the town-line between sec. 5, 62-10 and sec. 32, 63-10, on the west shore of the bay, the underlying rock is a greenstone, firm and tough, and very dark-colored.

The rock of the *Palisades*, which is a name given here to a nearly perpendicular wall of reddish, fine-grained syenite in the S. W. ¼ of sec. 4, 62-10, on the north side of the bay, recalls,

both by its physical aspect, and by its orthoclastic composition, the rock of the Great Palisades, on the north shore of lake Superior. It stands in a rudely columnar and slightly sloping position, rises from the lake level to the hight of forty or fifty feet, and extends along the lake shore about twenty-five rods. Long columns fall away. Yet this rock is the red syenite along here. Elsewhere, also, in the bay in sec. 9, 62-10, and along the bay into which the river flows from the S. W., the same red fine syenite appears. This red syenite (979), which sometimes seems very hornblendic, continues to the gabbro contact, S. W. ¼ of sec. 9, 62-10, where, so far as can be made out, in the timbered and moss-covered condition of the rock-hills, the transition is similar to that seen at Duluth, viz.: by a series of veinings in the gabbro, and a dissemination of red weathering feldspar in it, some patches in the gabbro being real syenite (rather quartzose) but fine-grained. The real gabbro character is established after a few rods of such mixed rock. When the phenomena are all condensed, the impression left on the observer is that the gabbro overlies the syenite, though there is here no such concrete observation.

Mr. Stacy visited an iron locality in sec. 30, 62-10. It is in the midst of gabbro rock, in the west half of the S. E. ¼ of the section, and the exposed iron surface, varying more or less to rock, occupies an estimated area of about thirty acres. The ore is similar to that seen on the north shore of Birch lake, in sec. 24, 61-12, and two analyses show the following results, according to Prof. Dodge:

Coarsely crystalline, magnetic, iron, 48.05; Titanium.................. 2.44
Fine-grained, olivinitic, magnetic, iron, 61.27; Titanium..........none.

Gabbro forms all the shores and islands of Gabbro and Bald Eagle lakes. Through the central part of the town (62-10) runs a very hilly country, the gabbro rising from 200 to 300 feet above the lakes lying to the north. The ridge in the southern part of sec. 22 was visited. It shows in some places large veins, or dikes, of a very coarse gabbro surrounding large areas of very fine-grained gabbro; some of the large crystals supposed to be of augite were collected for preservation. This ridge here rises according to aneroid 185 feet, but at points further west it rises 50-75 feet still higher. The highest elevations seem to be in secs. 19 and 20 of the same town. But the elevation does not consist of a single ridge, with ascent from both directions, but rather of an irregular succession of ridges and hills of some-

what varied shape, the whole presenting, when viewed from the north, the aspect of a prominent and connected line of hills.

We ascended the river toward Isabella lake as far as the supplies we had, the time at command and the frequent rapids would warrant, which was about two miles above Bald Eagle lake, and near the town-line crossing. About two-thirds of this distance the river is wide and smooth. A considerable tributary (the south branch of Birch river) joins the east branch in the N. W. ¼ of sec. 5, 61-9. A long portage and many rapids were to be encountered, further up stream. Gabbro rock continued as far as the examination went, the same as noted in sec. 22, 62-10, forming hills from 50 to 100 feet high along the south side of the river. I walked to the upper end of the portage, and from all that could be seen it was judged probable that gabbro rock continued to and even beyond lake Isabella.

Almost anywhere that any dip can be seen in the gabbro, it shows a coarse-bedded structure that dips southerly, at least away from the area of the syenite.

The fine syenite which extends from the gabbro contact in sec. 9, 62-10, northwardly along the westerly side of the water that runs from sec. 9 to the next town north, and into 63-10, to the fork of the Kawishiwi, sec. 26, is represented by four specimens numbered 979, taken from different places to show its variations. This is, altogether, the same rock as the palisade rock of sec. 4, 62-10. It lies here next north of the gabbro, and apparently under the gabbro, though no large exposure was seen showing this relation—the best being at the Archway rapids,* in sec. 9, 62-10. Here the gabbro has the usual coarse bedding, and the syenite itself sometimes seems to show the same structure and dip, indicating a coarse alternation and grand superposition of parts.

At the gabbro-syenite contact in the N. W. ¼ sec. 25, 63-10, there is no opportunity to learn the stratigraphic relations of the two rocks. The gabbro runs inland from the shore, making a bluff about 25 feet high. Then on the beach, which is low, and boulder-strewn for 15 or 20 rods, are large pieces, some of them probably not much removed from their natural positions, of mixed rock, orthoclase gabbro, syenite veined with fine red-weathering syenite, and some coarse gabbro. These run along to the little point, westwardly, where a fine-grained syenite

* These rapids are so named from an arch of gabbro on the east side under which a part of the water runs, and sufficiently high for a man to pass upright.

appears, mixed with veins and beds of coarse syenite, and with some changed igneous rock, the latter being now a mica-schist —though of this but very little—the whole apparently running below the gabbro.

Kawishiwi river. This river unites with Birch river waters in Farm lake, in the north part of sec. 34, 63-11, and from that point this name is given to the united stream down to the debouchure into Fall lake. The Kawishiwi originates in numerous small streams and lake basins that lie in T. 63-6, the highest principal lake basin being lake Polly, in the southern part of that town. In the same region are the sources of Poplar and Temperance rivers which flow southward, and of the streams which flow northward to Ogishki-Muncie and Knife lakes.

This river was explored as far eastward as the eastern shores of Wilder lake. The upper part of the basin of the river lies in the gabbro area, so far as examined, and probably this rock extends as far as its highest source. Yet in the next town east of that, in which lake Polly is situated, a red underlying syenite appears unconformably below the gabbro.* The description of the geology will be given in the order of examination, viz., from sec. 26, 63-10, where the river forks, eastward through the south channel to Wilder lake, and returning through the north channel in 63-9, and westward to Farm lake.

Syenite forms the shores from the fork of the river eastward to the S. W. ¼ of sec. 19, 63-9, where the river covers again the line of contact about a mile and a half.

In the bay covering most of the S. E. ¼ of the N. W. ¼ of sec. 19, 63-9, is a little island which must lie nearly on the contact line between the gabbro and the syenite. This consists of a firm, tough, contortedly gneissic rock of a dark color (purplish on fresh fracture) which is aphanitic, quartzless, and weathers red in some places. It has many veins, i. e. such seams as have been described above in the mica-schist in the northwestern part of Vermilion lake, each seam, on being weathered, being harder than the adjacent rock, causing a sharp ridge on the surface, such ridges crossing and reticulating with each other and varying in hight from a mere film that can hardly be traced, to half an inch or more. This rock seems to have been once in the form of a breccia, but not greatly displaced in its parts—perhaps only plastic. Some open spots have lost weathered-out fragments that were softer. In other places this rock looks as

* Tenth annual report, pp. 99-101.

if an igneous rock, now fine and diabasic, and hardly distinguishable from the rest, had been interfused with the broken fragments. There is a general, gneissic, coarse, perpendicular structure that runs east and west. This island rises but four feet above the water, and is only about twenty-five feet in diameter. The same rock appears on the mainland, just north of the island, and also west of it, and rises twenty feet above the lake. It is a rock which seems to vary from diabase to felsyte, and contains cherty spots. The gneissic structure is not common. (980).

Lying to the southeast from the foregoing island are a couple of other small islands, situated near the contact with gabbro. These consist of a very hard quartzose biotitic gneiss, the structure running east and west, standing about vertical (981).

Proceeding northward from the river, into sec. 18, 63-9, about half a mile, through the forest, the surface ascends about 100 feet, and the rock is a fine-grained diabase, similar to the rock at the shore (980) in nearly all places (987). There is no distinct structure or bedding of any kind, but in some places a sort of lenticular flowage structure, seen on a weathered surface, like that in some of the changed graywacke south of Fall lake, although the rock, as a whole, has more resemblance to true doleryte. (Compare 996 and 997.) It has a marked tendency to a coarseness of crystalline grain, giving it a gabbro-like character and color (988). Such coarse gabbroloid rock forms the summit of one of the subordinate ridges between the main ridge and the shore, and seems to be a part of the main rock-structure. Two or three ridges, separated by sharp valleys, generally with perpendicular rock-walls facing north (sometimes also facing south), intervene between the river and the centre of sec. 18, 63-9.

At the rapids in the S. E. ¼ of sec. 17, 63-9, the gabbro, which appears here on both sides of the river, is very fine-grained and like a diabase, indicating that the rock 980 is only a condition of the gabbro. On the supposition that it is the contact condition of the gabbro, the gabbro must overlie unconformably the red rock (palisade rock), the quartzose gneiss, which has a distinct uniform and persistent bedded-gneissic structure E. and W. (981) as well as the gneissic syenite which sometimes is seen along here, near the gabbro boundary. This supposition apparently is confirmed by the existence of the igneous rocks Nos. 987 and 988 at so much higher levels, on the north side of the

river in sec. 18. This shows that there will be found outliers of gabbro rock, in the higher levels, at points somewhat further north than the boundary line expressing its general northern strike on the accompanying geological map. The following sketch-map (Fig. 46) of this part of the Kawishiwi valley will convey an idea of the position of these rocks.

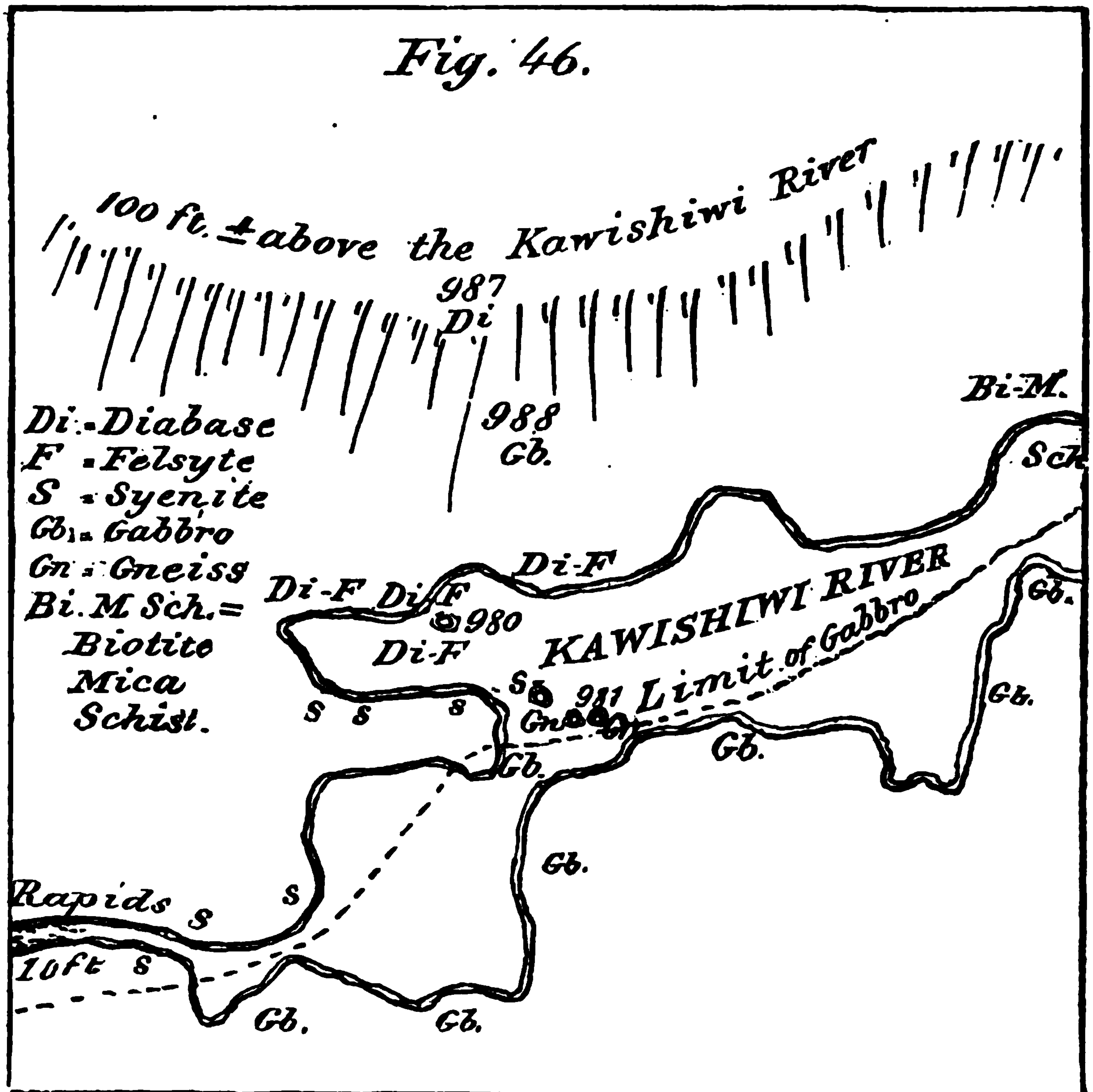

Fig. 46.—*Sketch-map of a part of the Kawishiwi valley, sec.* 19, 63-9.

The relative position of these parts is further shown by Fig. 47, which is a profile across the river from N. W. to S. E., passing through the islands.

A generalized perpendicular section, expressing all the facts observed respecting the gabbro contact, as they appear to be related by all the observations foregoing, may be constructed as shown in Fig. 48.

There are two grand groups of rocks here involved. One is

of direct or immediate eruptive origin, and embraces also the modified portions that are produced by coming into contact with the sedimentary beds. The other is of sedimentary origin and embraces the modified sedimentary masses. The former includes gabbro, fine gabbro, olivinitic gabbro and "muscavado," also the orthoclase-gabbro, or dioritic syenite and the diabase and dark felsyte. The latter embraces the fine syenite, the red, felsitic "palisade rock" of the Kawishiwi, gneiss, the quartzose and biotitic gneiss, and the porphyritic syenite. The last express the last term of extreme effect of the eruptive rocks on the sedimentaries, having resulted from complete fusion, and acting in all respects, among the other rocks, as an eruptive one. Many of the so-called dikes of this rock (or rock resembling this) are believed to be of chemical origin, and not connected with any source of molten rock.

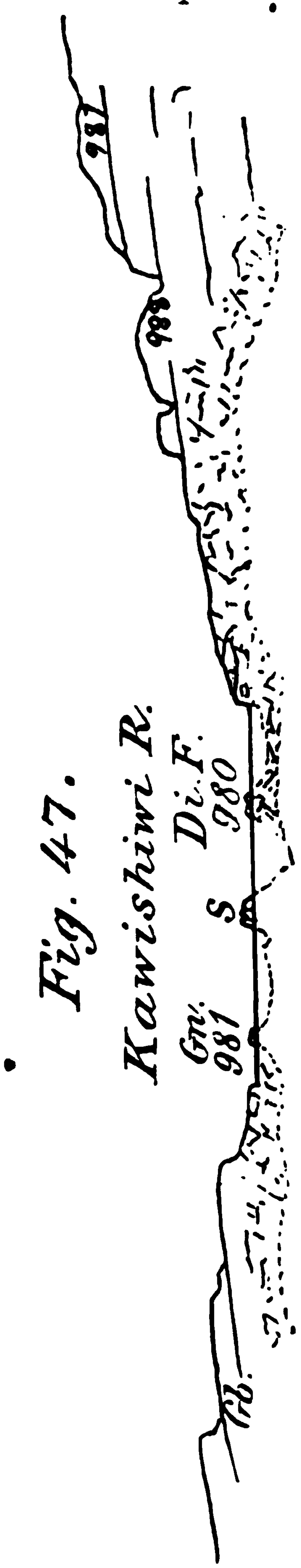

Fig. 47.—Profile across the Kawishiwi, showing the gabbro-contact.

In passing eastward, through town 63-9, the river divides in the S. E. ¼ of sec. 17, but unites again in sec. 27, embracing an island. This island is itself also divided into two parts by a subordinate forking of the river, making really three channels of flowing water occupied by the same stream—the north, central and south channels. Where the river first divides, the greater part of the water goes out by the channel that passes northward into sec. 27, and sec. 22.

The gabbro rock continues, by way of the south channel, to form the country rock, the elevations along the shore not exceeding thirty feet above the water, to the east side of the town, and also into T. 63-8. In passing through the last town, the land appears but little above the lake, the small undulations not exceeding ten feet, and the larger not more than twenty-five.

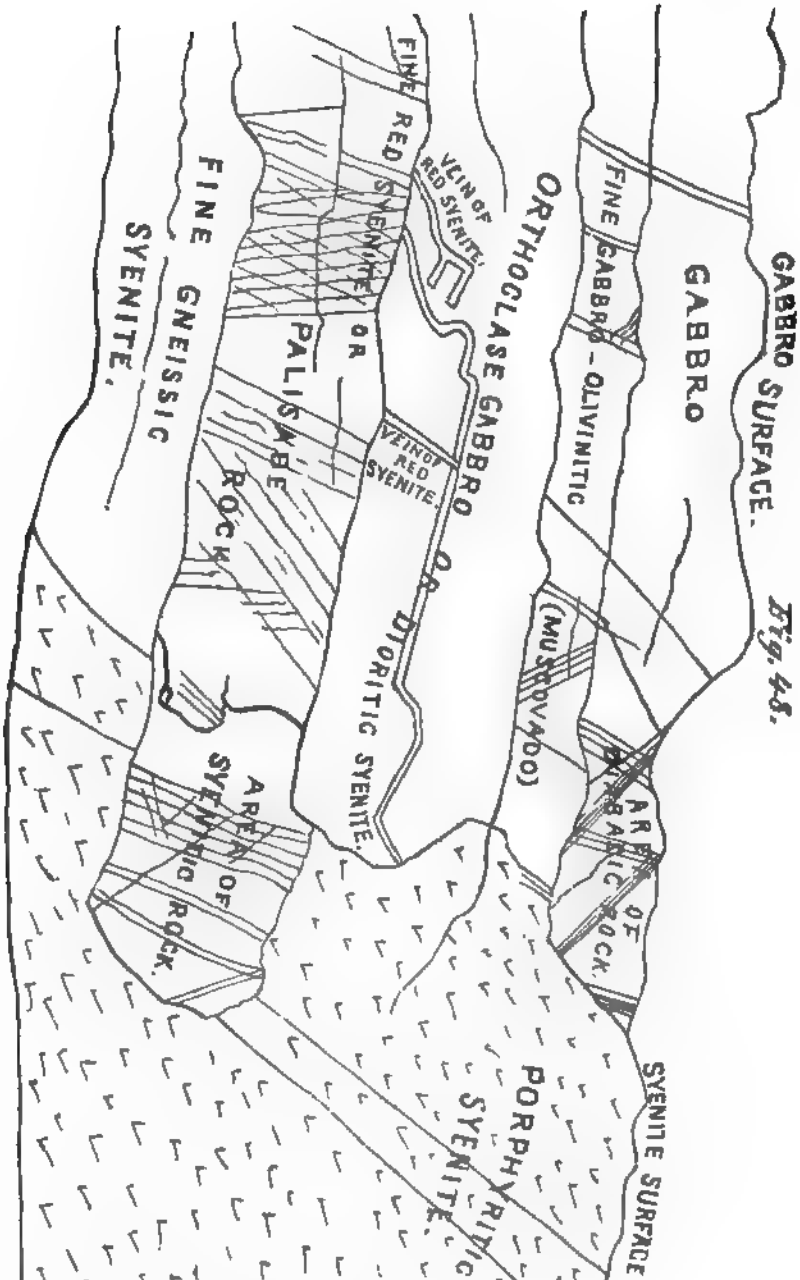

Fig. 48.— *Generalized section of the gabbro-contact on the sedimentaries.*

There is here no visible drift, or nearly none, except such as is referable to this rock. There are fine exhibitions of the process of making "*boulders by disintegration*," some bluffs being in process of decay but strangely retaining, undecayed, rounded boulder-like masses from two feet to six feet in diameter, the surrounding rock being so rotted that it can be picked to pieces by the fingers. There is no show of drift action — nor ice action, the rock everywhere being superficially crumbling off in flakes and in small bits so that in some of the bays the beaches consist of gabbro sand. There is not a total absence of transported drift, but only very rarely a boulder of granite. These also show the disintegrating action of age. The gabbro bluffs do not look clean and smooth-cut, but are falling down *in situ*, the joints being worn out so as to produce little channels in which water runs down to the lake. Old weathered surfaces are pitted with holes of all sizes, up to a hen's egg. On the tops of the hills is a thin, often gravelly, soil produced by the decay of the gabbro rock. The sand of the beaches in small bays where it gathers is made up of labradorite crystals, more or less rotted. The whole of Wilder lake has these driftless characters. They seem to show that at the last glacial epoch this region was not subjected to moving ice. This kind of surface extends from the west side of the lake in sec. 33, 63-8, eastward at least as far as the east end of Wilder lake, beyond which this trip did not extend. Throughout this area, although the rocks are bare much of the way along the shores, not a glacial scratch nor a glaciated surface could be seen, although on our return special notice was given to this feature. At the west end of the lake in sec. 33, 63-8, was seen one moutonéd surface, but it had no scratches. Gradually in passing still further west the rocks assumed a more preserved condition, and occasionally a rounded surface appears, and at the entrance of the main river, southern part of sec. 30, 63-8, is a striated rock-surface, the lines running S. 8° E. Further still west, such surfaces are more and more common, and finally every surface, facing toward the north, is found to be striated, and all the rock is hard and fresh. This interesting series of change can not be ascribed to any differences in the nature of the rock, because it is the uniform gabbro formation all the way, but must be referred to difference of glacial action. I think I saw also more frequent signs of transported drift about at the point where striated surfaces began to appear, though the drift in this part of the state everywhere is scant.

The more eastward direction of the marks noted above in sec. 30 is also significant. There was a little local disturbance of my needle at the point where the striation was noted, but an allowance was made for this by comparison with the direction of the needle at points near at which no disturbance was noticed. The normal direction of ice-flow in this part of the state, as noted further west, is S. 12° to 25° W. Hence the east margin of the ice-flow, which, according to Chamberlin, would have an outward movement from the axis toward the edge of the glacier, must have been that which produced these divergent scratches, leaving the country further east still uncovered.

About the north ends of the N. E.–S. W. lakes in secs. 15 and 16, 63-9, is an interesting series of exposures repeating the phenomena seen in sec. 19, 63-9, and showing pretty well that the rock there designated Di-F, or *diabase to felsyte*, is only a condition of the gabbro, and that the contorted gneissic structure which is rarely seen in it is superinduced by some local circumstances. Here the same rock, while showing frequently a coarse, often twisted and broken gneissic structure, also has a heavy bedded structure dipping in the same direction as the gabbro and conformable with it. The gneissic structure seen here runs N. 30° W. and is nearly vertical.

This rock not only varies to a gabbro, but also to an olivine-biotite-gabbro, or biotitic schist of fine grain, though the mica is not so arranged in it as to constitute the gneissic structure of mica-schist, but is rather uniformly distributed throughout the rock. There is in it also no quartz, that which might be taken for quartz at first, being rusted and rotted toward the weathered surface and crushing easily. No. 982 represents a series of specimens procured at various places showing different conditions of this biotite-olivine-gabbro, or biotitic schist, all from the N. E. ends of the little N. E.–S. W. lakes mentioned in secs. 15 and 16, 63-9, mostly in the rusted, semi-decayed and "muscovado"* state. No. 983 is an undecayed sample of the same. This has the clear gabbro-gray color, but is fine-grained. It consists very largely of the prevalent feldspar, but has much scattered black-mica. No. 984 is a quartzose biotite-gneiss from the same locality. As near as can be judged, from all the appearances, the downward transitions are as follows, though there

* This field-term was subsequently brought into use, and continued as a designation of this form of the great gabbro formation. There is certainly a no more exact comparison that could be made of the visible outward characters of this rock than to liken it to the "brown sugar" of commerce.

is no regular succession in vertical order, the variations being horizontal as well as perpendicular:

1. Gabbro, coarse-grained.
2. Biotite-olivine-gabbro, sometimes contortedly gneissic.
3. Diabasic and felsitic, dark-colored, rarely becoming gneissic and involving similar fragments that are fine-grained and welded with itself.
4. Quartzose biotite gneiss, unconformable.

The rock 983 continues southwestwardly through sec. 16, 63-9, and in the S. W. ¼ of the section it rises in bluffs from ten to thirty-five feet high on the south side of the north channel, constituting a large member of the gabbro rock. It is again represented by 985, but here appears to hold also olivine.

A similar fine-grained olivine rock or olivine-gabbro, extends along the north shore of the river in sec. 17 and 20, 63-9, but in the northwest part of sec. 20 the rock 986 appears near the water, which is a very fine-grained, gray micaceous quartzyte, or gneiss, belonging to the foregoing No. 4.

Near the centre of sec. 26, 63-10, on the south side of the lake, the outcropping syenite is very hornblendic, making a nearly black rock. In patches, however, is seen a fine red syenite, the transition from one to the other being abrupt. The red syenite becomes at once the prevailing rock. This fine red syenite is much developed, in hills about 50 feet high, in N. W. ¼ of N. W. ¼ of sec. 26, 63-10.

On the N. W. ¼ of sec. 27, 63-10, is a rock that is represented by 989 (four samples), a fine-grained, firm, slightly micaceous, quartzose (and also feldspathic) gray rock, with evident bedding (i. e. sedimentary) planes dipping east, 50° south, at an angle of 75° from the horizon. It resembles, at a glance, the graywacke of Vermilion lake, in color and grain, and almost every respect. The few mica scales seen are not of biotite, but are greenish. It is nothing different from some of the beds associated with the graywacke of Vermilion lake. It resembles 984, except that it shows no black mica. Across the river, N. N. E. from this rock is a nearly white gneissic rock, a kind of feldspathic graywacke, dipping N. E. his has some reddish-weathered spots. In the line of strike east from No. 989 is a small island in the lake, so near the shore that it can not be of any other rock than 989. It contains rock 991, and, while it is gray within, and has the same gneissic or faintly bedded structure, it weathers light-red and at a distance might be taken for fine red syenite.

A little east of 990 appears 992, a kind of chloritic syenite.

This is massive, or heavily bedded, without gneissic structure, weathers red—apparently an eruptive rock, at least being outwardly disposed like an eruptive. It is closely cross-jointed, making small, lenticular, angular blocks. It continues east along the north shore (993), as far as the quarter-post of sec. 22, and becomes the red syenite noted further east. On the point between the two bays, on the south side, N. E. ¼ of sec. 27, 63-10, the rock is the same as 991, and dips southerly, but with a less evident gneissic structure. Finely twisted and back-folded bedding can be seen on the weathered surface, like some seen in the graywacke on sec. 20, 62-15, showing a former plastic, or nearly plastic, condition. In the midst of it appears rock represented by 994, which is a fine red syenite. This is taken at random from the surface of this graywacken gneiss. It is sub-crystalline, yet contains many fragmental grains. The color is light-red, sprinkled through, or about evenly divided with, a light-green, the former being apparently orthoclastic and the latter chloritic. This shows the possibility, nay, the actuality, of this graywacken gneiss becoming the prevailing red syenite of this region, the whole having resulted, as already intimated, from a modification of the sedimentaries. This graywacken gneiss, when fused completely, seems to have produced the rock 993. When changed less it constitutes the "palisade rock" of this region, and mingles with the gabbro. When less changed it makes the red-weathering fine sub-crystalline gneiss. This interesting observation, while it may not account for all the red syenite, and the gneiss of the region, yet affords a plausible supposition for the origin of that which is closely associated with the gabbro rock. It seems that no theoretical conclusions based on mineralogical paragenesis and on microscopical inspection of thin sections can be brought to bear adversely on so conclusive field evidence as is here afforded within the space of a quarter of a mile.

Another form of the modified sedimentary rock is 995, which succeeds to the rock 991 in the N. W. ¼ of sec. 28, 63-10. It is hornblendic, quartzose, orthoclastic—at least has reddish feldspar grains (not crystals)—micaceous, gray, firm. It makes the long rapids here, and rises in the form of a ridge running N. E. and S. W. in the direction of the strike of the rock 991, rising about 80 feet above the river. The dip is southeasterly, at an angle of 80° from the horizon. Along the immediate river channel this rock rises on the right and left somewhat in the

manner of the red syenite or "palisade rock," nearly perpendicular, having a jointed and pseudo-basaltic appearance.

At the foot of the portage-trail which passes, on the north side, round these long rapids, N. W. ¼ sec. 28, 63-10, but a little to the north, is a hill-range made up of a different rock (996). This is similar to that which makes the Kawasachong falls, and also resembles the rock 987. This is a heavy, basic rock, of eruptive origin, much confused, containing some quartz veins conformable with the flowage structure, and some red-weathering crystals or patches. From this place the ranges seem to bear away somewhat N. of W. since, at the beginning of the next rapids, on the north side of the river, a syenite, like 993, appears as a "palisade" bluff. This is in the north part of sec. 29, 63-10, near the north section-line. Syenite rock forms the rapids also in the N. E. ¼ of sec. 30, and continues to the town-line between 63-10 and 63-11, sometimes varying to a gneiss, which again varies to mica-schist. This mica-schist can be seen on the south side of the river in the S. E. ¼ of sec. 30, and a quarter of a mile further west on the north side. At the town-line the bluff on the south side is about 30 feet high and consists of syenite.

For a description of the remainder of the Kawishiwi valley, from the town-line to Farm lake, in 63-11, consult the report of A. Winchell.

GENERAL THEORETICAL SECTION OF THE FOREGOING DESCRIBED ROCKS.

A provisional attempt may now be made to group the descriptions that have been given of the chief hill-making rocks in some systematic stratigraphic scheme. It seems to the writer that the rocks are related stratigraphically to each other as expressed by the figure (49) that follows.

Fig. 49.

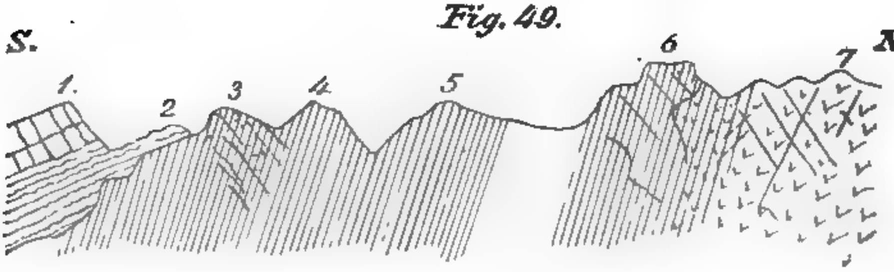

Fig. 49.—*General geological section.*

EXPLANATION OF FIG. 49.

1. Gabbro; this seems to have been poured out and spread over the upturned sedimentary beds that preceded it. In its lower portions, where it came into contact with the sedimentaries, it was variously modified into No. 2, and also embraced and transported masses that were detached from the sedimentaries. It probably issued from innumerable vents, but the points of issue were probably arranged somewhat as the rock is distributed, i. e. in a longitudinal series running from Duluth to the boundary line at Gunflint lake. This is a true eruptive rock and came from a deep source within the crust of the earth. It forms the great Mesabi range, and is iron-bearing, the iron generally being titanic.

2. Diabasic doleryte. This also takes the forms of olivine-bearing and biotitic gabbro ("muscovado"), especially when the gabbro boundary is adjacent. When the gabbro boundary is more remote, this rock alone seems to make important hill-ranges, and is then not so apt to be biotitic. In some places this is a conspicuous rock, and in others it is of not much account in a topographic sense. It causes the falls of Kawasachong, extends along the south shore of Fall lake in both directions, east as far as the Pipestone rapids, hardens the graywackes south of Long lake, lies on the jaspilyte at various places, and by incipient decay is converted to a more or less fissile chloritic schist, and in this state seems to pass sometimes for a sericitic schist. This is a true igneous rock.

3. Reddish gneiss and syenite, both coarse and fine grained. The "redrock" of earlier reports, particularly that associated with the gabbro along the Mesabi range. The Misquah hills are composed of this. The syenite of White Iron lake, and that of the Giant's range ("Messaba Heights") are supposed for the present, to be extreme exhibitions of the outburst of this rock. It seems to be due in this last case to a fusion of the sedimentary beds *in situ*, and the protrusion of the molten rock through the openings that may have existed in the adjoining strata. Still in most cases there was no complete fusion, but a more or less advanced recrystallization of the sedimentary strata *in situ*, as in sec. 27, 63-10. This has been regarded as of Laurentian age.

4. Broken and hardened graywacke, sericitic schist, argillyte, quartzyte and jaspilyte. This member is protean in its composition and variations. It seems to include most of the rocks about Vermilion lake, except the schists of the Vermilion group, and such of the schists or other modified rock as may prove to be of eruptive origin in the southern part of the lake. The argillitic slates are simply a variation from the sericitic schists. The jaspilyte and ore are sometimes a magnetic quartz-schist, and sometimes nearly black. This seems to graduate conformably into the next.

5. Mica-schist, hornblende schist and diroyte. *The Vermilion group.* This graduates conformably into a gneiss and to a granite, which has been regarded as of Laurentian age. On the other hand where No. 3 graduates into the bedded sedimentaries, it is apparently always syenite, and has been regarded Laurentian.

6. Mica-schist and granite veined with syenite and granulyte. This is the lower portion simply of No. 5.

7. Lower syenite and gneiss, generally regarded Laurentian.

There are a great many unsettled problems yet involved in the

geology of these rocks, the solution of which can not now be given. When they are investigated — and some of them must be before the above scheme can be considered demonstrated — they may show that it is necessary to vary from this generalization. There are some reasons for believing the Animikie rocks overlie the greenstone (No. 2 above) and underlie the gabbro. It is only designed here to express, so far as the work of the survey has progressed, what grand results of stratigraphy and rock-genesis are indicated.

FROM FALL LAKE TO THOMAS LAKE.

Felsitic schist, probably a rotted condition of the felsyte (or porodyte) that forms Stuntz island, is the rock causing the rapids at the N. E. end of Fall lake, sec. 3, 63-11, but in some places further down, a glittering micaceous schist appears. On the portage trail this schist is seen to be sometimes fine and almost flinty. (1109.)

Basswood lake. At the beginning of Basswood lake (pipestone rapids) the rock consists essentially of the green rock (or a green rock) which has been supposed above to be of igneous origin, and a syenitic gneiss. There is a perpendicular contact of the two visible in the bluff on the right side of the river about six rods below the foot of the "falls." The green rock, however, rarely shows its original condition—a perfectly preserved doleryte, but varies to a hornblendic rock, and to a fine mica-schist. Tremolitic schist seems also to be one of its conditions. The greatest change of this kind is seen near the top of the bluff, and along the open seams and at the point of contact with the syenite. The cliff on the left bank I did not examine, but it had the general jointed aspect of a basaltic rock, and seemed to be either wholly eruptive or so affected by igneous contact that it has acquired an igneous facies.

The syenite is closely jointed, nearly perpendicularly, so as to present a basaltic structure, simulating sedimentary bedding. It is rather fine to medium grained.

In section 6, 64-10, at the west end of the portage the rock is mica-schist and syenite, but mostly the former, having conformable and approximately conformable bands and veins of syenite, as represented by 1108. It is a firm rock, having a bedding, or at least a fibrous lamination that runs south, 60° west. But this structure is often interrupted by nodules of syenite, and is con-

torted and curving, and seamed, holding some veins of chemical quartz that extend in the same direction. This mica-schist is part of a prominent belt that strikes S. W. from sec. 6, 64-10, across the bay, forming islands and hills, into secs. 1, 11 and 15, 64-11. The rock is firm, having a firm, leaning, columnar, pseudo-basaltic jointage, which is cut perpendicularly by another set of planes that from certain points of view cause a semblance of sedimentary bedding to appear dipping N. W. about 40°, and the upright basaltic and schistose structure dipping S. E. about 75°.

The island crossed by the section line between secs. 11 and 12, 64-11 (the northerly one), is made of what appears to be a fine-grained, dark, firm, fibrous, siliceous, actinolitic schist (No. 1026). It rises fifty feet above the lake. The rock has a distinct strike, about N. 45° E., and dips S. E. about 75° from the horizon. This shows no banding like sedimentation, but a finely streaked and schistose upper surface. In these streaks are involved different minerals, the principal one apparently quartz. Sometimes the streaks are arranged on the weathered surface like

Fig. 50.

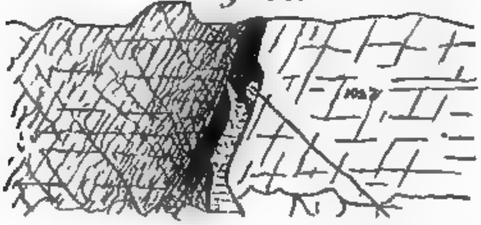

Fig. 50.—*Apparent igneous rock changed to mica-schist.*

that which is attributable to igneous flowage, seen on diabase rocks. Throughout it, runs the finely fibro-schistose structure or rift, which causes it to disintegrate in sheets, and irregular blocks and flakes elongated in the direction of the strike; cut, however, transversely by jointage into somewhat sharply angular forms. It has very much the aspect, at a distance, of a sedimentary schist. Still it can all be supposed to be a modified eruptive rock. If so it is not allied to the green chlorite schist which at Garden lake results from a change of diabase, but is probably of older date, and belongs in the Vermilion group.

On an island in the lake, in sec. 1, 64-11, another distinct contact can be seen in this old group. It is represented by Fig. 49. It runs nearly perpendicular from the water.

In the contact plane is developed a quartz vein about a foot wide. The rocks here concerned are as follows:

1027. Gneissic syenite quartzose, reddish, medium-grained, apparently becoming micaceous by change, on the right of the contact.

1028. Micaceous dark rock, from the left of the contact, but near the quartz. This contains a thin, reddish, granulyte vein. This is dark-colored, and though micaceous is not a mica-schist. The other minerals are difficult to determine, but there are evident quartz and red feldspar.

1029. About one foot from the contact, evidently cemented by a quartz frame-work, but contains mica and reddish orthoclase.

1030. Dark, reddish-gray, siliceous, fine-grained, massive, but rather coarsely jointed.

1031. Similar to 1028, fifteen feet from the contact.

These two rocks, by their color, jointage and general facies, show a noticeable contrast. The evidence is not conclusive that the dark rock was originally igneous,— nor that the light-colored one was originally sedimentary, but the gist of the whole, in the light of other observations, rather indicates it. There is, however, more evidence that the dark one is sedimentary than that the light one is eruptive.

The rock of Northeast cape, sec. 23, 65-10, is represented by No. 1032 — a fine-grained gneiss which is micaceous rather than hornblendic. It weathers red, though it is gray within, sometimes showing the warped and lenticular inclosure of masses of apparently some other rock round which a schistose flowage structure is developed.

This rock (1032) is cut by two bands of dark gneissic rock, represented by 1033. This appears to be a micaceous, quartzose dark gneiss similar to No. 1030. These bands run about E. and W.

It is also cut and ramified by rock 1034, a sort of coarse vein-rock, or reddish granulyte, apparently containing the same minerals as 1032 (except mica), but in larger crystals. This is probably of chemical origin. Rock 1033 is also cut by veins of light-colored granulyte, but less coarse.

On the portage from Ensign to Illusion lakes. Argillitic slate appears near Ensign lake, N. E. ¼ sec. 14, 64-8, fallen in detached masses so as to lie in discordant strike in various positions. About half a mile further a ridge of modified graywacke and of

schistose slaty argillyte, rises about sixty feet on the north side of the little creek, and the portage trail passes over it. Its strike is N. 65° E. At the east end of this portage, near the centre of sec. 13, 64-8, rock No. 1035 is exposed at several points. It is a fine-grained, dark-gray, heavy rock (olivinitic?), which appears in some places schistose (E. and W. and vertical) though not with that fine schistose lamination seen in the chlorite schists; but much more coarsely and brokenly-irregular-flowage lamination, the parts being connected by vein-matter which shows a rigid reticulation on the surface when weathered. It seems in the main to be a sedimentary rock, though apparently invaded and sometimes permeated by igneous matter. Very rarely can a distinct sedimentary banding be seen, though this veining and this schistose structure, being in the usual direction of the strike of the schists and sedimentary beds, would very easily pass for sedimentary structure.

Illusion lake. The north shore of Illusion lake has several outcrops of the same rock (1036) as the last described, with occasional better evidence of sedimentary structure. The strata (?) stand about vertical, or dip toward the south 80°–85°. As a sedimentary rock, it would be designated in the field a fine, gray, arenaceous quartzyte. But it is heavy, and considerably resembles some form of the gabbro rock near its contact with the sedimentaries. It is greatly broken and recemented. On a little island near the southwest shore, this rock, or a similar one, is contorted; and although bedded, and like sedimentary rock in its apparent structure, it is twisted like some of the graywacke seen at Tower, dipping in opposite directions on the same surface at intervals of twenty feet. The main strike seems to be northeasterly, but the convoluted condition of the strata, imitating that of some of the jaspilyte, will not justify any statement that can be relied on as to strike.

The south half of this lake has shores of gabbro (1038). It first appears, on the east side of the lake in the form of 1037, a muscovado gabbro, finely granular, somewhat gray or yellowish.

The curiously involved and convoluted bedding seen in the rock on the small island above mentioned, and in other places about this little lake, as well as at other points where this horizon is encountered, seems to pertain to the under portion of the gabbro, the irregular contortions being due to flowage over the uneven surface of the older rocks.

From a small island, a little south of the island above de-

scribed, was obtained No. 1039, which is a biotitic gneiss, the same as seen at the most northern turn of the Kawishiwi, and at the same relative position respecting the great gabbro overflow.

At the portage from Illusion lake to Ima lake the trail passes over a ridge of gabbro that rises perhaps seventy-five feet above Illusion lake.

The shores of Ima lake are formed of gabbro entirely. The stream which enters the east end of Ima lake expands into a lake in sec. 20, 64-7, and also again in sec. 29 soon after it leaves Thomas lake.

Thomas lake. The entire shore of Thomas lake, and all its islands, consist of gabbro in some of its modifications.

On the N. E. ¼ of sec. 29, 64-7, a little west of the meander corner of secs. 28 and 29, the gabbro assumes a very ferruginous character, even constitutes a fair iron ore, but it exhibits only a small outcrop at the beach. The needle is disturbed by it. The chief other ingredient of the rock is olivine. In other places near here the gabbro is not noticeably ferriferous, but is olivinitic. This ore is No. 1040.

Near the central part of Thomas lake, in the N. W. ¼ of sec. 33, 64-7, are three isolated crags of gabbro standing out of the water, having fantastic forms. These were named Liberty cap, Sphinx and Pyramid islands.

Frazer lake is similar to Thomas lake, in its geology. It even has a similar magnetic iron ore deposit on its north shore, (S. W. ¼ sec. 14, 64-7) formed by a ferruginous spot in the surrounding gabbro. A good quality of ore can be obtained here (1041), but it might be badly affected by titanium. At the place of this iron deposit, a few years since, some mining was done *for gold!* The works were in the gabbro rock. The owner precipitately abandoned the place, refusing to carry away the assaying apparatus, and the chemicals, mining tools, provisions, dynamite, and also the "assayor" under whose guidance the work was carried on, involving an expense of several thousand dollars. The man who was abandoned was taken away subsequently by some Indians. A forest fire injured some of the property, but the shanties, the chemicals, hammers, drills and assay jars, cupels, forge, anvil, etc., still remain, a testimony of ill-guided cupidity, such as becomes infatuated with the belief that wherever some "experienced miner" declares coal, or iron, or gold exists, there it is safe to expend money in search for it.

About the shores of the lake in the river, in sec. 11, 64-7,

appears the intermediate, gneissic, biotitic gabbro (1042) which here seems to embrace pieces of other rock and has contorted bedding and flowage structure. It resembles in all these respects the phenomena seen on the islands in Illusion lake. Here it appears as the lower part of the gabbro. Indeed the most northern exposed rock seen on this lake is a true gabbro, but fine-grained and rusted, having the aspect of muscovado sugar.

The ridge which separates the lake in the river, from Kekekabic lake is formed apparently by a fine-grained greenish rock. The north declivity is over a hundred feet, but the south side descends not more than ten. This green rock is probably a somewhat rotted condition of the fine-grained lower part of the gabbro.

Kekekabic lake. At the southeast end of Kekekabic lake, at the head of the little gulf projecting into sec. 11, 64-7, the rock that appears at the shore is represented by No. 1044. This rock is speckled with light flesh-red crystals apparently of orthoclase. It is sub-crystalline throughout, but its grained-color is gray. It is another illustration of recrystallization of the sedimentaries in the vicinity of disturbance. This was apparently a graywacke rock at first.

Fig. 51.

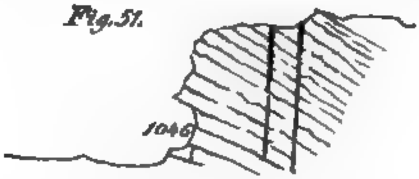

Fig. 51.—*Profile of the south side of an island in Kekekabic lake.*

The same rock extends along the south shore of Kekekabic lake through secs. 2 and 3, 64-7, but becomes more and more red and syenitic. (Nos. 1045 and 1046.) It also constitutes the islands in the lake that are situated in sec. 3, 64-7 (Nos. 1100, 1101). The aspect in general is that of a thin-bedded gneissic (syenitic) rock, the bedding dipping southerly about 25° from the horizon. On the island near the centre of sec. 3, 64-7, a bedded structure is brought out to view by weathering, and is not that of sedimentation, only so far as its direction may have been due to that cause. It is now rather the coarse undulating bedding that is often seen in igneous rocks, that have been in flow. This dips about 25° N. and is crossed by joints that give it a coarsely columnar aspect when viewed from certain directions. Fig. 51 shows the profile of the south side of this island.

The most westerly island is represented by rock No. 1100. This is a reddish syenite, but was a fragmental rock originally. It has a rather fine, lenticularly schistose jointage that is irregular in its direction and in its fineness. On the north side of this island this rock is less red, and grayish-green (1101) though still having some red orthoclase mingled with it somewhat porphyritically. This shows a nearer approach to the original grayish sedimentary condition. It is a firm rock, with free quartz, sub-crystalline, and apparently a mixed syenitic metamorphism after some graywacke. It is sparingly spotted with what appear to be forms of boulders and pebbles due to an original conglomeritic condition.* These are now greenish, or micaceous, contrasting markedly with the mass of the rock. There is visible sometimes not only a conglomeritic, but a sedimentary, banded structure, dipping 30° from the horizon, south 10° west. Yet the most conspicuous bedding is that which dips 30° to 40° N. 10° E. This (latter) causes on the south side sometimes a perpendicular or overhanging bluff, by the underwear of the lake. This somewhat undulating, north-dipping bedding is what I have called sometimes provisionally a flowage structure, and it may be due to that, since when it is most developed the sedimentary banding is invisible. The sedimentary banding is visible most distinctly at the southeast angle of this island. Here was sketched Fig. 52.

Fig. 52.

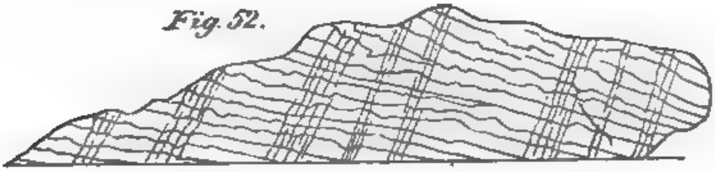

Fig. 52.—*Profile view of the westerly island in Kekekabic lake.*

The largest island — Animikie island — is represented by rocks 1102, 1103 and 1104, the first from the west end, the second from the northwest corner, and the third from the east end of the island. The first is the same quartzose syenitic rock as 1101. The second shows red and gray variations, due probably to difference of composition in the original, and the last is greenish, fine-grained, heavy and diabasic, probably the same as the original of No. 1043.

There is a little island northeast of Animikie island situated

* Compare the Sauk Rapids gray "granite."

in the N. W. ¼ of sec. 2, 64-7, which consists in the main of this same firm syenite. But it is porphyritic, at the same time that it is conglomeritic. This is shown by No. 1105, from the north side of the island. A little further toward the east was obtained No. 1106, which is a biotitic crystalline rock, gray in color but porphyritic with flesh-red feldspar, and blotched by pebbly forms. A single specimen shows all these characters. It is fresh and hard. This must have been very near the transition point from the biotitic gabbro to the older sedimentaries, and shows a mingling of the characters of both, the original clastic rock having been a conglomerate. The porphyritic crystals are developed both in the pebbles and in the matrix, but in the former are numerous reddish grains that are not perfect crystals, giving the areas of the pebbles a very distinct contrast with the gray matrix. The biotite scales or crystals are scattered, so far as seen, only through the general matrix. Some of the pebbles are of green chloritic rock.

It seems that the gabbro sheet must have extended considerably further north at first, covering the sedimentaries and changing them by its heat, and that by glacial and other atmospheric agencies, its northern limit has been driven south, uncovering the modified rock. Thus —

Fig. 53.

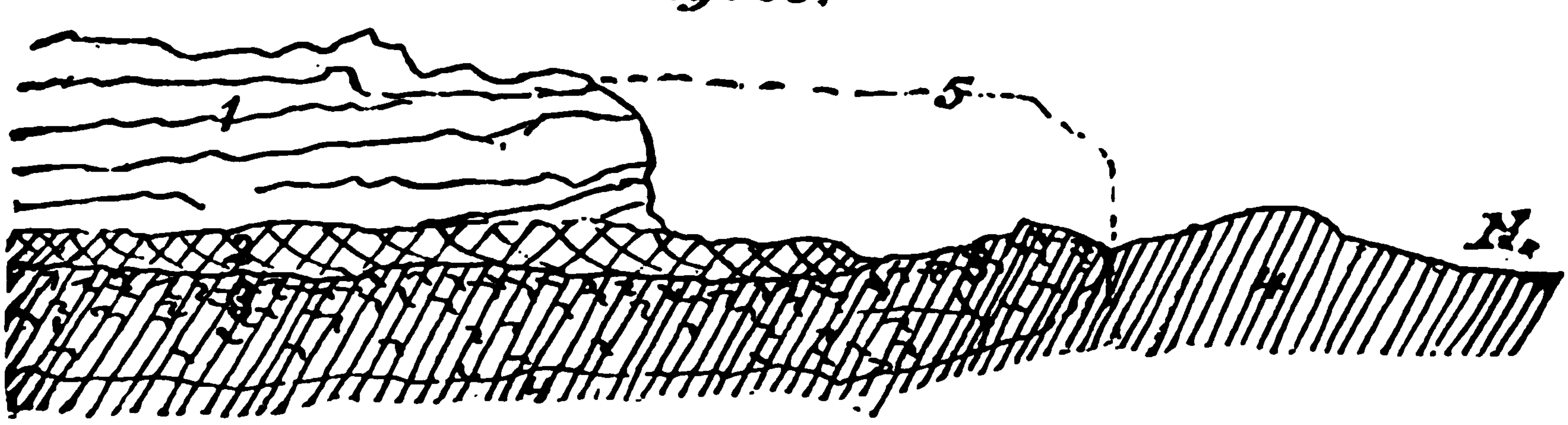

Fig. 53.— *Theoretical northern border of the gabbro and its relation to the sedimentaries.*

EXPLANATION OF FIG. 53.

1. Gabbro sheet.
2. Contact layer of the gabbro sheet, sometimes diabasic, and sometimes biotitic and fine-grained.
3. Modified upper surface of the sedimentaries.
4. Unmodified sedimentaries.
5. Supposed original limit of the gabbro sheet.

At the southwest corner of Kekekabic lake, S. W. ¼ of sec. 3,

64-7, the rock 1047 embraces 1048. The former is a fine-grained gabbro-like rock, not typical gabbro, but evidently that condition of the gabbro sheet which is always met near the northern limit, and the latter is in sub-angular and rounded pieces, and sometimes seems to shade into the inclosing rock, or at least to become so intimately united with it by cementation that no line of distinct transition can be seen. It appears finely granular—even as finely granular as the disintegrating jaspilyte of the iron-bearing rocks at Tower. Its color is gray, and were it not so finely granular it might be considered the same as the "muscovado" rock before mentioned—which indeed it may be in its nature and origin. Most of the inclosed pieces are rounded. The inclosing rock, 1047, weathers away much faster than these inclosed pieces, and hence the rough outward appearance caused by the projecting knobs of 1048 gives the weathered surfaces a jagged and forbidding aspect,—particularly when approachd in a gale, in a birchen canoe.

At the same time this coarse, apparently fragmental rock, is replaced, at intervals, by a rock that is seamed in all directions like the diabasic schist, or biotitic gneiss, seen in so many places, the seams being firmer and persistent, while the mass of the rock wears away, producing a reticulated network of prominent and finer sharp ridges all over the exterior.*

An eighth of a mile northwest of where Nos. 1047 and 1048 were obtained (where no distinct prevalent dip could be seen, but apparently a grand structure dipping S. W.) is an appearance of the same red rock as 1046, dipping W. N. W. It forms a bluff about ten feet high, but does not continue far, for the lower part of the igneous formation returns, exhibiting the same characters, in a bluff that continues along the west shore of the bay in the east side of sec. 4, and rises 25 or 30 feet perpendicularly. In this bluff only the lower part appears to be pebbly (1049); while the top appears to consist of a fine-grained gabbro (1050), some of it having disseminated red crystals, making an orthoclase-gabbro (1051).

When this orthoclase-gabbro comes into contact with the red-rock (1052) it acquires the orthoclase element. One such contact is seen a little further north—at the W. ½ of sec. 3, 64-7—on the point, and the red-rock dips S. S. W.

Along the east half of the south side of the little bay at the N.

* A photograph was made of one of the larger fallen weathered fragments as it lay in the water near the bluff.

E. corner of sec. 4, 64-7, a fine-grained nearly black rock (1053) strikes nearly E. and W. and along the west half it strikes N. E. and S. W. and at the depth of the bay the overlying pebbly igneous rock appears on a sharp little point. This rock is evidently one of the fine-grained of the fragmental series. It has a bedding that dips conspicuously at an angle of 45°-50° east, then E. 30° N., then N. W., then N. then easterly again. This seems to have been some argillitic portion of the graywacke series. As metamorphosed and broken, it appears as a petrosiliceous black rock, showing grains of quartz. No. 1054 shows the nature of the weathered surface, on which is a finely reticulated network of projecting siliceous sheets that seem to rise from the interior of the mass, but may be only siliceous matter that had accumulated in the open joints prior to the commencement of the weathering process. This is sometimes a slaty rock, and sometimes a black slate, but generally a distinctly bedded, nearly black, brittle siliceous rock. It resembles the Animikie slates which run along the international boundary eastward from Gunflint lake.

The pebbly gabbro, which becomes chloritic by decay (Nos. 1049 and 1050), extends along the west and northwest side of the bay that projects north in sec. 34, 65-7, and becomes a lenticularly and coarsely schistose greenish schist (1055), the edges standing vertical, illustrating a transition to schist exactly like that which has been described on the west side of Garden lake. This schist holds rounded pebbles. It also has in its seams a pinkish orthoclase associated with quartz (1056). It is cut by a greenstone dike running nearly E. and W. near the shore, in sec 34, which is about eight feet wide. Along the shore in the N. W. ¼ of the S. E. ¼ of sec. 34, 65-7, the same siliceous rock as Nos. 1053 and 1054, again appears, with a distinct, and almost continuous, dip nearly south, about 80° from the horizon. East further in the same section, and in sec. 35, the chloritic rock becomes a conglomerate. It is crowded with rounded, or subangular, foreign pieces. It is sometimes schistose, sometimes gneissic, sometimes massive and nearly always pebbly. No. 1057 represents this rock when not pebbly nor schistose, from near the meander corner between secs. 35 and 36, 65-7, on the north shore.

This chloritic-schist-conglomerate is, in some places, rather more micaceous than chloritic, and sometimes it approaches the graywacke in appearance, showing a sedimentary banding. At

the portage that runs north to a little lake (Pickle lake), near the east side of sec. 34, all these features can be seen by making a little examination right and left from the trail. At the north end of this portage the rock is graywacke and slate at the landing, but south from there, the strip of land over which the trail goes contains a rather chloritic sometimes conglomeritic rock. The sedimentary banding when visible runs in somewhat variable directions, but seems to be in general east and west; and the prevailing dip is south when the beds do not stand vertical. There is a coarse-schistose, vertical structure produced in these beds nearly everywhere due to disintegration, and quite often a heavy pseudo-bedded structure that dips easterly or southeasterly about 45°. This last is more properly a jointage, and appears where the heat and metamorphic action of the gabbro overflow, which may be considered once to have extended as far north as to cover this, had its influence on the old bedded rocks. This is visible near the point west of the portage landing on the shore of Kekekabic lake (sec. 34) and dips ten degrees east of north. At the same time at the water's edge, and elsewhere, the usual sedimentary banding demonstrates the true dip to be S. 40° E. about 78 degrees, and the slaty-quartzyte stratification is brought out plainly by the action of the weather and water.

The hill near the shore, N. W. ¼ sec. 36, 65-6, is represented by the rock 1058. This hill, in the main, consists of a pebbly and conglomeritic rock, the forms of the pebbles appearing on the weathered surfaces, but there are also large areas on the weathered surfaces where it does not show any contained pebbles. The rock is green, massive, firm, medium-grained. The conglomeritic patches exhibit, sometimes, on the weathered surface, a banding that appears to be due to sedimentation. In the interior, when freshly broken the conglomerate does not exhibit its composition. On weathering, a lighter color is given to some of the stones. The whole mass is coarsely jointed, non-schistose. But the same rock, along the shore in favorable positions, becomes schistose. It seems as if the great Ogishke conglomerate in some way is involved with and gives character to, the diabasic rock which is here represented. Probably its pebbles, freed from their matrix, are again embraced in this, and perhaps large masses of itself were detached, involved in the eruptive mass, worked over by fusion, and now produce the variations we see. In other cases the banded structure of the original is preserved, and is evident when exposed to the elements.

At the N. E. ¼ of sec. 36, 65-7, on the north shore, is a different phase of this green rock, rising almost perpendicularly from the water nearly 100 feet. This is not schistose, but jointed, and falls in blocks (1059). It is a firm, green, fine-grained rock, spotted with light-green, and sparkling with porphyritic crystals of apparently hornblende. Compare rock 751.

At the narrows of Kekekabic lake, which is at the town line between 65-5 and 6, is the porphyry rock 1061, and the relation it bears to the foregoing chlorite-schist-conglomerate is shown near the water line, where the following diagram was sketched. It rises through the green rock, leaving a small amount of the latter on the south side, between it and the water.

Fig. 54.

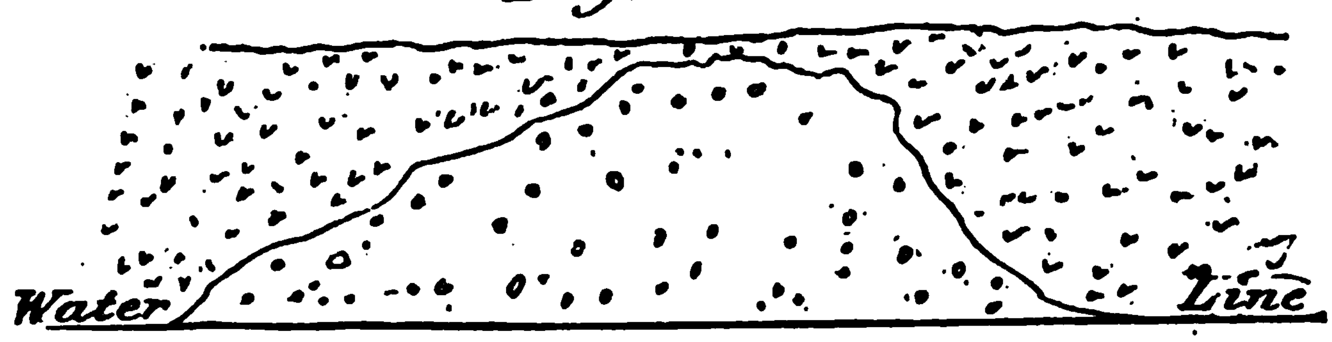

Fig. 54.—*Relation of the porphyry No.* 1061 *and the chlorite-schist-conglomerate. The porphyry rises up through the chlorite-schist-conglomerate.*

In the chlorite-schist (1098) here sketched the structure runs E. and W. and has an abrupt contact with the porphyry No. 1061. The porphyry is not only porphyritic but conglomeritic. The feldspar crystals are nearly white. It contains plainly a considerable amount of free quartz (1061 B.) In it are also crystals of biotite. The ground-mass is granular, gray and sub-crystalline. The feldspar crystals compose about one-third of the entire mass. The rock shows nowhere a sedimentary banding. Some of the pebbles are from six to ten inches in diameter, and water-rounded. These are all (now) of the form of some greenstone (1061 A), and present a contrast with the nearly white-weathered surface of the rest of the rock. This rock forms an isolated rounded knob near the lake shore, rising about 40 feet, and extending back about 15 rods, where, after a valley is passed, rises a high ridge of hardened graywacke weathering green and appearing almost like a true greenstone, though showing sedimentary banding. This second ridge rises about 150 feet, and appears at the lake shore on either side of

the porphyry, the latter rock being the cause of the northern shore swelling a little southward, causing the narrows of the lake. This green ridge is in the continuation of the rock 1058, 1059 and 1097, all being hardened (or later rotted and fissile) phases of the graywacke-slate-conglomerate formation, but sometimes so involved with the lower part of the gabbro overflow that they can hardly be distinguished from the diabasic condition which that assumes near the contact. The porphyry (1016), which acts the part of an igneous rock, is evidently a condition of the slate-conglomerate after fusion, and comes up like an eruptive rock through the green, hardened graywacke Nos. 1060 and 1098.

The green ridge mentioned continues northeastwardly, and culminates in Mallmann's peak which rises about 230 feet above the lake in the S. E. corner of sec. 30, 65-6 (1095). It would seem that the bed of Kekekabic lake is excavated in the green conglomeritic rock resulting from the contact of the gabbro overflow on the graywacke conglomerates.

The point which has the section corners of secs. 29, 30, 31 and 32, 65-6, north shore of Kekekabic lake, is made of porphyritic rock similar to that last described at the narrows, represented by No. 1094. It is wholly worked over from a conglomerate, some trace of the pebbles being yet visible, in changes of color, and in aggregations of different crystalline minerals in nodules, seen in spots on a fresh surface. It is one of the steps in the metamorphism of the conglomerate of Ogishke Muncie lake, but little less profound than that seen at the narrows. This is in the direct line of extension from that. This is a grayish rock (resembling 1078), and the crystals that are most conspicuous are those of a nearly white, but sometimes reddish, feldspar, apparently orthoclase, and of a greenish mineral that looks like hornblende, but the whole matrix seems to be as nearly crystalline as the situation would allow. It is rather tough, but not so tough as a doleryte. Very small quantity of free quartz can be seen.

West of this point a dike of doleryte runs from Mallmann's peak, and appears in the lake in the form of a couple of small islands. These islands are nearly on the section line between 30 and 31. The dike, which is 18 feet wide, has a marked contact phenomenon on each side, and a selvage streak separating it from the slate, etc., through which it runs. Its direction is 10° W. of S.

The rock No. 1062 is a recurrence of the porphyry. Nos. 1094

and 1061. But this is further east,— S. E. ¼ N. E. ¼ of sec. 28, 65-6, near the narrows of Zeta lake. It lies to the east of a greenstone dike which runs along the water's edge, cutting the slates. It rises in hills on each side of the narrows from fifty to seventy-five feet. It falls down in angular basaltic blocks along the beach, and has a firm resistance to the weather. It is plainly, at first, porphyritic, but on closer examination it is not only seen to be also conglomeritic, but the porphyritic spots appertain largely to the inclosed pebbles. In other places the crystals are disseminated through the matrix, which is a dark, or dark-greenish rock like a diabase. This does not show any schistose structure here, but it shows occasionally the linear distribution of parts which is so like sedimentary banding that one would refer it to the action of water in distributing the materials, were it not so plain that the rock has taken its position and condition through the action of eruptive forces. The crystals of feldspar are apparently orthoclase, but there is in the rock a large constituent of hornblende, or changed hornblende. There is in it occasionally a pebble, but each such pebble has undergone a recrystallization, and has been so blended by partial fusion, with the matrix that in many cases the outline is not distinctly defined; but the existence and size of the pebble are now indicated by the greater or less frequency of the light (nearly white) crystals of feldspar. The rock was fragmental originally, so far as outward characters indicate its original condition, but now is crystalline by metamorphism, the force producing the metamorphism having acted so powerfully as to cause a plastic if not a fused state of the constituents.

At a point a little to the west (across the strike) from where 1062 was obtained this rock is more plainly a conglomerate, and not so generally porphyritic.

On the point, S. E. side of sec. 29, 65-6, Kekebabic lake, the exposed rock is hardened and reformed by metamorphism from the slates and conglomerate. It was pebbly and fragmental originally, but greenish, nearly homogeneous, basaltic and apparently eruptive now. No. 1093 represents the finer portion of the rock.

Ogishke Muncie lake. On the north shore of the long bay from Ogishke Muncie lake, N. W. ¼ of sec. 27, 65-6, the slates and graywackes are conglomeritic (1063), the latter being sometimes quartzytes. These finely conglomeritic beds are separated by dark, light-weathering, laminated, slaty argillitic rock in bands

of about the same width (3 to 10 inches), and have a S. S. E. dip about 75°. Yet all round this bay this great conglomerate prevails on the east and west sides rising in hills 20 to 30 feet high, coarsely jointed, and not presenting the banding that indicates the bedded structure of sedimentation.

No. 1064 fairly represents this conglomerate about this bay. In places it is simply a dark, tough, doleryte-like rock with igneous jointage, and in others (1065) it is porphyritic and conglomeritic, containing flint, jasper and quartz in foreign pebbly masses.

At the narrows going out from this bay, near the centre of sec. 27, 65-6, the same conglomerate is found, but here it has less the eruptive appearance. The graywacke beds are rather a gray quartzyte, sometimes pebbly, and make up the most of the whole, the only sign of bedding due to sedimentation being a banding that is produced by more pebbly belts (running E. and W.) and a linear grooving on the non-pebbly belts caused by the weathering out of some of the elements faster than others. The whole mass can be said to be a quartzyte and conglomerate.

The pebbles included can be identified as follows: Flint; porphyritic flint, or felsyte (both being gray unless weathered); quartzose, light-colored granulyte; white quartz (both limpid and milky); diabase (fine); diabase (coarse); and banded jasper (red). The light-colored granulyte and the doleritic rocks form the largest included masses and are most numerous.

At the shore, on Ogishke Muncie lake, a little west of north from Campers' island, the fragmental conglomerate is basaltic at the water, and rises about fifteen feet nearly perpendicular. On the top of the hill can be seen a banding of sedimentary structure, consisting of alternations of coarse and fine belts, dipping south, 65° from the horizon. It is also evident by the contorted flowage structure brought out by weathering on the upper surface, that the whole mass has been plastic, the sedimentary bands being obliterated or broken, and in their place substituted a slow-bending and undulating set of fine striations that turn on themselves and change direction when abutting against some other masses that are banded with sedimentation.

At a point a little further east the same rock rises about 35 feet in the same way.

East of the central narrows, which are in the south part of sec. 23, 65-6, on the north shore, N. E. ¼ of the S. E. ¼ of sec. 23, 65-6, the slate and quartzytes stand vertical, or dip north 80°.

A basaltic conglomerate appears again on the north shore S. W. ¼ of the N. W. ¼ of sec. 24, 65-6.

Along the second narrows, on the east side, and south of the narrows, is a curious condition of the conglomerate. It is schistose, almost fissile, and small chips roll down the bank not larger than ½ inch or 1½ inches in diameter. These cover the undisturbed rock surface from the water upward. In some places the rock stands out entire. When it is wholly disintegrated the thin rusty chips are from ⅛ to ½ inch in thickness, making the bluff look like one of drift. On the top (1067) the rock is coarsely disintegrated by wedge-making joints. It is here also greenish, and finely porphyritic in the matrix, yet pebbly and sometimes more firm. There seems to be a chloritic element produced in the matrix by change from some original mineral.

Fig. 55.

Fig. 55.—*Section across the shore of Ogishke Muncie lake.*

The above diagram is a section across the shore of Ogishke Muncie lake, a little north of the second narrows, on sec. 24, 65-6, east side.

1. Doleryte, scantily conglomeritic. At other places along here this is abundantly porphyritic, and then weathers into a rusty schist.
2. Swampy. No exposure.
3. Carbonate of iron (and calcite?). This is the same as No. 746, obtained further west in 1879. It runs here in a low rusty ridge, holding angular pieces of siliceous loose rock which stand out on the surface. This ridge extends in the direction toward that seen in 1879, and here rises about 10 feet. It seems likely to be of the nature of vein-deposits. Its thickness here may be fifteen feet, but it embraces considerable schistose foreign matter.
4. Swampy.
5. Gray quartzyte, fine-grained, rises ten feet.
6. Slates, sedimentary, standing vertical, the slates being due to sedimentary bedding; interstratified with some coarser beds that are more like the gray quartzyte. Rises 20 feet.
7. Lake level.

The whole distance across from No. 1 to No. 7 is about ten rods.

No. 1 is represented by rock 1068, and No. 3 by rock 1069.

At the rapids where the stream goes out from Ogishke Muncie lake to Town Line lake, the rusty schistose conglomerate No. 1068, appears in the water and causes the riffle. (No. 1070.)

About Frog Rock lake the rock, so far as examined, is entirely of the igneous doleritic kind, slightly conglomeritic, except at one place on the north shore where the sedimentary rocks appear, and are slightly conglomeritic. This last is near the N. W. corner of the lake. This lake was not thoroughly examined, but according to what is known the green doleryte would run along the southern side and past the eastern end. The rock of the principal point projecting northward from the south shore is represented by No. 1071, being a porphyritic, greenish rock (a diabase) with crystals of some pyroxenic mineral, resembling 1059. At the extreme east end of the lake appears 1072, a fine-grained greenstone, with pyrites.

At the mouth of the stream which enters Ogishke Muncie lake from the south was taken the following diagram. Fig. 56:

Fig. 56.

Fig. 56.—*Diagram of a superposition of rocks at the mouth of Ogishke Muncie creek.*

1. An overflowing rock, having the jointage, action and aspect of an eruptive rock. 1073.

2. Irregular stratum of the same holding fragments of fissile, closely jointed, baked slate which is thin and black, and crumbles in the slope, of which 1074 is a sample. Rock No. 1075 shows the contact of these two rocks, and the consequent blending of characters.

3. Fissile black slate, closely jointed, baked, separated into thick beds; the upper and lower sides of which undulate, the general dip appearing to be S. E. but so faulted and twisted that it can not be determined. The whole slate exposed is about fifteen feet, and the overlying rock rises about ten feet higher at the place of the diagram, but it spreads generally over the surface at some little distance back from the shore. It also extends westward, across the creek, and then spreads about over a distance of some rods, making some little hil-

locks, and is porphyritic (1078). The slates underlying are highly changed, sometimes wholly fused, or brecciated, and uniformly converted to a very closely jointed or fissile, fine (cherty) rock.

In going upward from here to the hills in sec. 35, 65-6, on the west side of the creek the following facts were noted: (1.) The sedimentary slates and quartzytes are broken, and dip in various, but nearly vertical, directions. (2.) The sedimentary beds become porphyritic with feldspar crystals, and apparently with some quartz crystals. (3.) They acquire a fluidal bedding, seamed and veined by quartz. (4.) They strike north, 20° W.; N.; N. 28° W.; N. 20° E., and generally dip E. or S. E. or S., toward the mountain, but their strike on weathered surfaces is often contorted, like the graywacke at Tower, and fragments are mixed with other kinds of beds, the beds apparently bending round them. (5.) So far as observed they are always full of free quartz grains, even in their apparently igneous outward aspects. The weathered surface is light-gray—or graywacke-like. (6.) Further up, at three-fourths of a mile from the lake, the strike is west 25° north, and the dip is 80° to 85° toward the S. W. (7). At the distance of nearly a mile from the lake, at 145 feet above it, the change illustrated by the accompanying diagram (Fig. 57) takes place. Here the sedimentaries dip N. at an angle of 50° from the horizon, 40° east, lying on the greenstone illustrated by sample No. 1076. On the top of this hill are scattered boulders of Saganaga granite, etc.

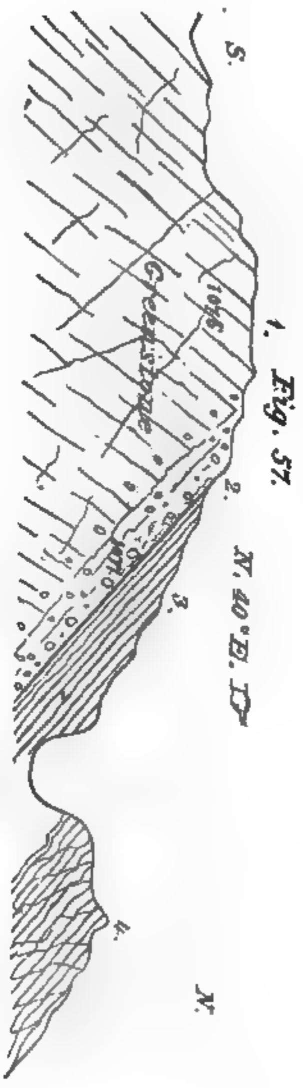

Fig. 57.—Showing the position of the slates and quartzytes relative to the greenstone on sec. 35, 65-6.

EXPLANATION OF FIG. 57.

1. Greenstone, apparently forming the mountain to the south, rock No. 1076, at 145 feet above Ogishke Muncie lake. This rock is tough, massive, and coarsely jointed.

2. Pebbly greenstone, 3 to 5 feet. Rock 1077. On the surface the line of contact, which, facing north, is glaciated, shows very distinctly, and the pebbles seem to be all of greenstone, or at least of some greenish rock, some of them quite fine-grained. The line of contact is shown by the next figure.

3 Hard, fine-grained, almost cherty, but black, beds of slate in distinct sedimentary arrangement.

4. Broken and contorted graywacke and slaty bed, seen about ten feet.

Fig. 58.

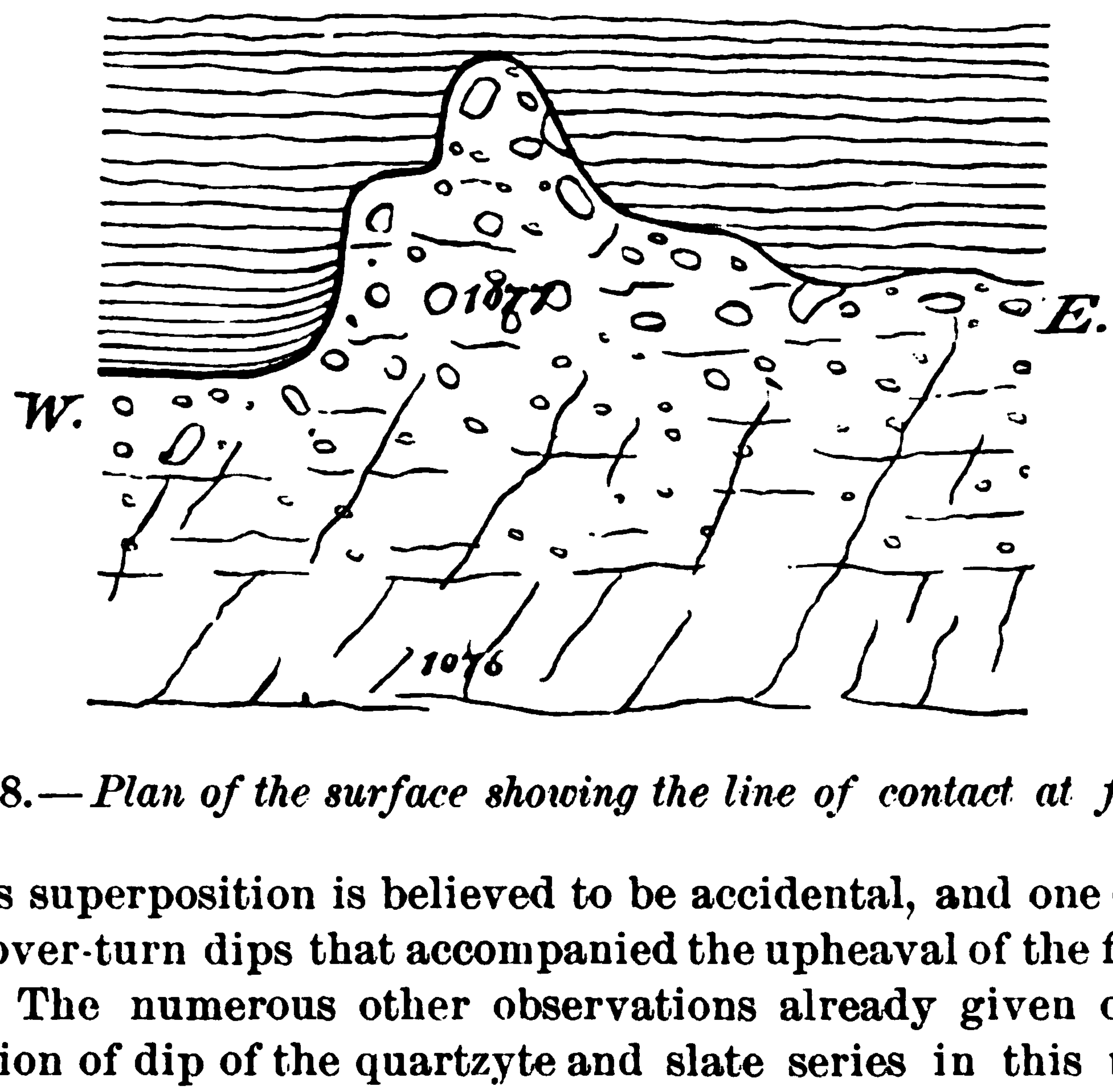

Fig. 58.—*Plan of the surface showing the line of contact at fig. 57.*

This superposition is believed to be accidental, and one of the local over-turn dips that accompanied the upheaval of the formation. The numerous other observations already given on the direction of dip of the quartzyte and slate series in this mountain show the frequent changes of direction to which it is liable. The correct stratigraphic sequence will require the quartzyte and slate rocks below the gabbro—if not below this greenstone.

We ascended only to a spur of the main hill, rather lying between the two hills that are in sec. 35, 260 feet above the lake. The hill which lies about half a mile further south seems to rise about a hundred feet higher, or 350 feet above Ogishke Muncie lake. The same rock as 1076 continues to and forms that hill, as ascertained in 1879.

No. 1079 shows a fair sample of the matrix of the Ogishke con-

glomerate, a third of a mile from the shore north from Campers' island, and 1079 A are pebbles from the same, i. e. near the centre of sec. 23, 65-6.

Near the N. E. corner of the S. E. ¼ of sec. 22, 65-6, the conglomerate is porphyritic with crystals of white and flesh-red feldspar (1080). But these may be only transported fragmental grains, which is indicated by the fact that they are somewhat rounded occasionally and are disseminated through a coarse, granular matrix in which are numerous rounded grains of quartz of about the same size, some fine red jasper, greenstone, and the other usual ingredients of the conglomerate. Sometimes, in a simply arenaceous portion of the matrix, or one of the uniformly but heavily bedded portions, the little points that stand out on a weathered surface are partly of feldspar crystals, and partly of quartz.

At about a mile and a quarter northwest from the same place on the shore, the formation ceases to be of conglomerate, and becomes prevailingly a siliceous black slate (1081), similar to that seen in sec. 26, 65-6, a short distance south from the south shore. About eighty rods further northwest an arenaceous texture appears in these hard flinty slates, and they are thicker bedded, though still separated by fine slaty layers. These heavy beds become greenish, and at the hill which is on the west side of the N. E. ¼ of sec. 22, they become converted into a greenish arenaceous graywacke that recalls the rock of the mountain south of Ogishke Muncie lake, but can not be the equivalent of that because this is fragmental, showing rounded jasper and quartz grains; it is also lighter-colored, its green color being due to its green matrix. At the summit of this hill it is evident that rock 1082 constitutes the bulk of the hill; but even here it is intersected by beds of 1083, a flinty "slate," greenish black, hard and finer than diabase. This is in bedded alternation with 1084—the same as 1082, a really fragmental rock.

Trip to lake Gabimichigama. From the west side of Little Reynard lake (which is between Ogishke Muncie and Fox lakes) was obtained rock No. 1085, near the water. This is a fragmental rock, even a conglomerate with pebbles of quartz and flint, evidently a part of the same great conglomerate, but it is blackened and hardened and changed, the quartz being the only original pebbly element that retains its form and distinctness. The flint and the red jasper are also nearly as perfectly preserved. This suggests the important inquiry whether by fusion this conglom-

erate could be converted to the rock of the hill 1076 — a perfectly characterized igneous rock — through the stages of the rocks 1073 and 1082. It is not probable, but at numerous places about the lake observations that have been made give rise to such a query.

On the N. W. side of Fox lake the slates and quartzytes are wholly broken and confused. The bedding is lost, and the rock appears almost igenous-massive. It is here mainly a changed black slate, there being now no suggestion, even, of its original condition (1086), an aphanitic, black petrosilex (?), or chert.

On the portage from Fox lake to Agamok lake the formation is not only beautifully and continuously long banded by alternating belts of slate and chert, but is also beautifully brecciated, the pieces of slate being of all sizes, from an inch or two to several feet long, inclosed in the coarser-grained graywacke, running zigzag and in isolated dike-like protrusions.

At the foot of Fox lake the north bluff stands up boldly above the water, consisting of a hardened and pseudo-basaltic, but coarsely jointed, condition of the quartzyte and slate formation. It is represented by fig. 59.

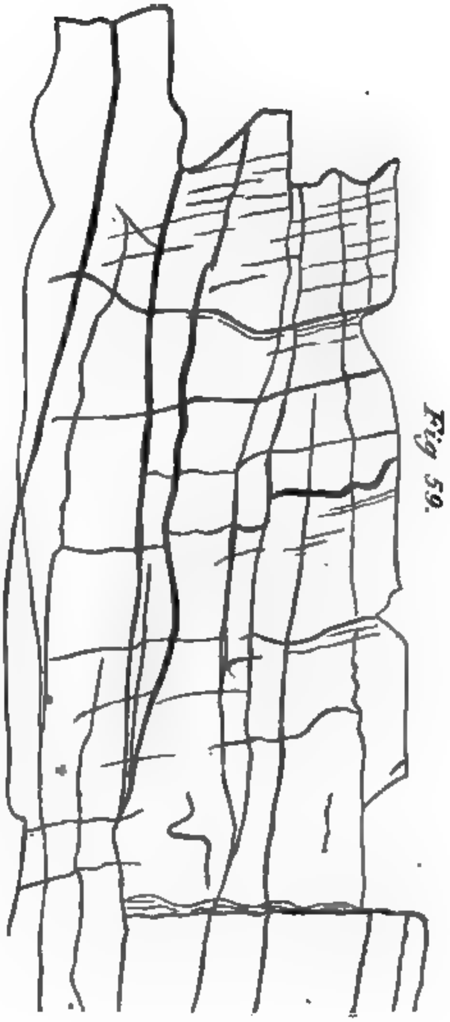

Fig. 59.—*Bluff at the foot of Fox lake, showing jointage in the hardened quartzytes and slates.*

In Fig. 60 (next page) the dark lines represent cherty, light-weathering beds; the white bands represent the interlaminated coarser beds. The mixture of crumpled and straight beds, seen in immediate contact and alternation, is the interesting and puzzling fact here. Many of the beds are so thin that they are no thicker than the pencil point, and on this reduced scale they can not be represented—nor one half of them. No. 1087 shows this rock when brecciated. The slates, being more refractory,

do not lose their identity in the general mixing and metamorphosing process.

Fig. 60.

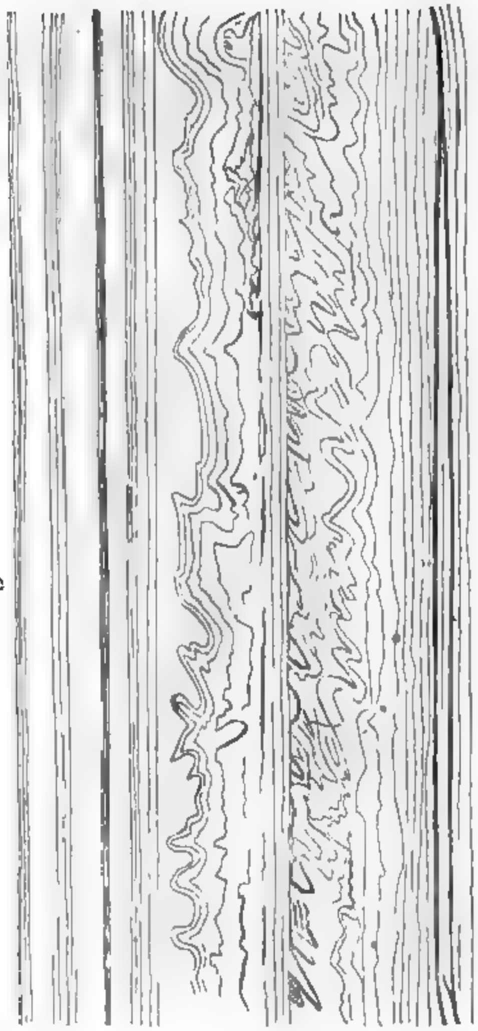

Fig. 60.—*Sketched from the surface, on the portage from Fox to Agamok lake; alternate straight and contorted bedding in immediate contact.*

Along the north shore of Gabimichigama lake in 65-5 the quartzyte-slate formation is seen in occasional low exposures, jointed closely and greatly changed, rarely pebbly, vertical (so far as can be ascertained) striking nearly N. and S. or N. N. W. and S. S. E.

The little island at the entrance to the bay forming the north-

easterly end of Gabimichigama lake contains this formation, and is represented by rock 1088. This rock is a rather fine-grained, arenaceous gray quartzyte. It shows no outward evidence of stratification. It takes a rusty color. It presents knobs and ridges all over the surface, that do not weather away so fast as the rest. It appears like some of the craggy rock that lies near the gabbro-contact at the S. W. end of Kekekabic lake.

At the west side of sec. 32, 65-5, the rock of the long point that projects westerly into the lake is not well exposed on the north shore. A bluff, however, rises, about midway of the point, and is composed of coarsely jointed heavy layered rock that shows a general structure dipping east about 45 degrees (1089). This is a siliceous, very much hardened fragmental rock, but its original sedimentary banding is obliterated by the action of the formerly superposed overflowing gabbro. It is the same as No. 1088, but shows an intenser action of the gabbro on the quartzyte and slate group.

On the south side of this point appears a fine biotitic gneiss (1090). This is apparently siliceous (with some grains of quartz) but in the main no quartz can be distinguished with certainty. Sometimes it appears chrysolitic. It is heavy-bedded, resembling in outward appearance the rock 1089, and dips also toward the east, at an angle of 30 to 45 degrees, this bedding, however, being due to a wavy system of planes separating it into sheets, and not to any variation in the rock such as is implied by sedimentation. This holds boulders of quartzyte, and apparently of other kinds of rock, but they are so assimilated to the enclosing rock that they are individually now unidentifiable. This rock crumbles in some places, allowing apparently boulder-masses to roll out; in such cases some of the glassy grains are yellowish, and indicate the presence of chrysolite, as mentioned above. Sometimes the whole of it takes the form of "muscovado" gabbro—which is a semi-disintegrated condition. The whole bluff along here seems to be on a parallel with that which was noted in 1879 on the south shore of this lake further west (rocks 767 and 768).

Fig. 61 represents a map and concordant profile section east and west along the south side of this point. It shows the irregular manner of bedded structure mentioned in 1090, and appertains to the outrunning overlie of the gabbro on the quartzyte-and-slate group.

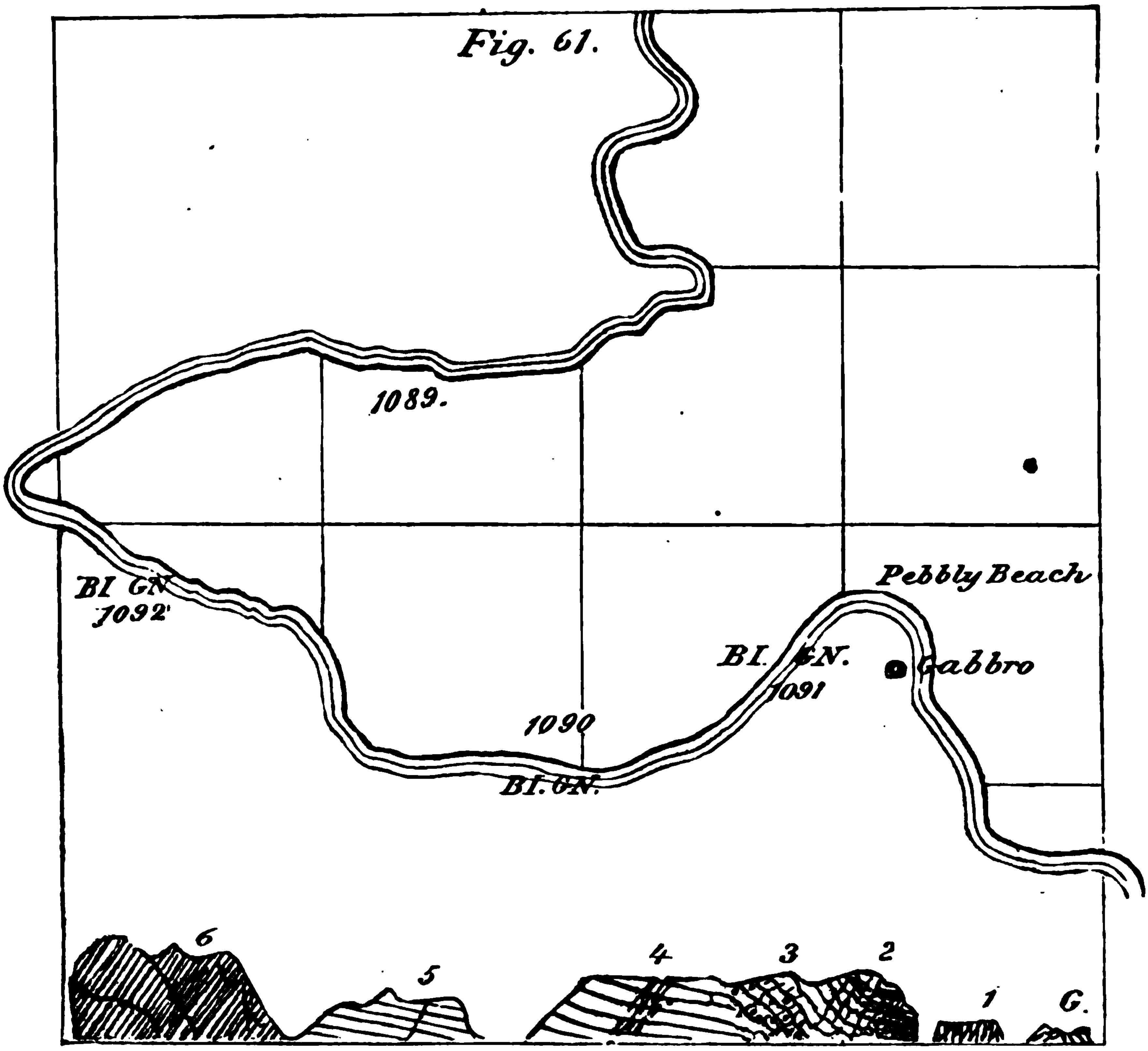

Fig. 61.—*Showing the gneissic, and yet bedded, structure of all the rocks at the bottom of the gabbro sheet. Sec.* 32, 65-5.

EXPLANATION OF FIG. 61.

G. Gabbro island. Gabbro appears in force along the lake further south.

1. Biotitic gneiss; confused, with no bedding nor strike, but apparently holding boulders greatly changed, all being siliceous. The prevailing jointage is vertical, and runs 25° W. of N. This has much the general aspect of some changed portions of the quartzyte-slate group, seen on the north side of this point.

2. Biotite gneiss, siliceous, irregularly jointed and disintegrating.

3. The formation here is siliceous and biotitic, but the biotitic portions are in streams, which, surrounding portions that are less micaceous and more siliceous and firm, disintegrate, disclosing boulder-like masses that fall out like "boulders of disintregation." There is now and then a striation that reminds one of the banding of sedimentation, as if a modified part of the quartzyte-slate formation of this region.

4. Here the grand bedding dips conspicuously toward the east. Along the water, generally, this rock has a knobbed rough upper surface, eroded by the action of the waves on the more or less micaceous parts. There is here a closely jointed portion that runs about N. E. and S. W. but slopes N. W.

5. Shows a plain-bedded dip eastward; micaceous and rotting.

6. At the end of the point the rock rises perpendicular and exhibits a plain sedimentary banding that dips W. 10° S. running from the water to the top of the bluff. This is a part of the underlying quartzyte-and-slate series. It is siliceous in bands, but throughout it are scattered fine mica scales.

This traced transition from the quartzyte-slate rocks to biotitic gneiss, and hence to the biotitic diabase (so called on the Kawishiwi river) in the immediate vicinity of the gabbro boundary, is an important step in establishing the genetic relations of these formations. There is here, however, nothing to be seen of the great greenstone formation which extends east and west through the country. That seems to lie further north, while this shows the gabbro contact without the greenstone accompaniment, direct on the quartzyte and slate group (the Animikie series), and the greenstones lie, at the west end of Gunflint lake, to the north from the south-dipping Animikie, it seems to agree with a large number of facts to suppose the Animikie series lies on the greenstone, or in its absence, on the Saganaga syenite. The westward extension of the superficial area of the Animikie seems to be cut off by the overlopping of the gabbro beyond its northern border, bringing the gabbro not only onto the greenstone, but at points further west onto the lower graywacke-slate series. This would place the Animikie series stratigraphically between the gabbro and the greenstone; and the greenstone would represent an overflow of basic eruptive rock much anterior to that of the gabbro. The Ogishke conglomerate is allied closely with the Animikie. It contains numerous greenstone boulders, and perhaps represents its basal portions.

North and west from Kekekabic lake. In making the portages from Kekekabic lake to Knife lake, the principal part of the descent being at the north ends of the portages, and the whole descent being 135 feet, each trail discloses only the graywacke-slate rock, sometimes greatly broken and seamed and at first rather greenish. On Spoon lake there seems to be a dike, forming at least two of the islands, cutting graywacke and slate.

Just at the north of the portage landing on Knife lake, near the west side of sec. 27, 65-7, is a light weathering knob of black or purplish flint (1107), belonging to the same formation as seen on the other side of Ogishke Muncie lake. But the graywacke-

slates appear before reaching the west end of Knife lake. The line of travel after entering Knife lake is nearly in the line of strike of the rocks of the region, and hence there is a sameness in the appearance of the rocky outcrops. The strata are from two inches, or less, for the argillitic portions to six inches, and even six feet, for the coarser beds. They are almost invariably either vertical or dip at a high angle toward the S. S. E.

5. THE GENERAL GEOLOGICAL MAP.

The preliminary geological map which accompanies this report is intended to show what is known concerning the geological boundaries, and also includes considerable that is guessed at. Wherever the reports describe the formations, they are known, but there are long distances that intervene between known points. Perhaps there is less certainty concerning the areal distribution and the stratigraphic relations of the greenstone belt (No. 6 of the legend of the map) than any other of the formations, and greater certainty of the correctness of the northern limit of the gabbro. The area of conglomerate and felsyte extending eastward from the southern confines of Vermilion lake may be continuous and identical in origin with the greenstone belt, but there are unsettled points that need investigation before such a connection could be affirmed. The graywacke and sericitic schist rocks are represented as covering this doubtful area.

There will be found also many variations necessary to be made from the regularity of the outline of the red syenite and which is involved with the gabbro in the eastern part of the map. The granite, syenite and gneissic areas are all represented by the same color, but this is not intended to express the idea that they are of the same age. The northern limits of the red quartz porphyry (No. 4) are uncertain. It is possible that there is no gabbro nor trap separating it from the red syenite further north, and that it will be found to blend into the red syenite, this being one form of metamorphism of a sedimentary rock and the red syenite another.

6. BAROMETRICAL ELEVATIONS.

Determined by aneroid readings by N. H. Winchell in August, 1886:

Garden lake above Fall lake ....60 feet.		White Iron lake above Fall lake, 90 ft.
Ascent by river (estimated)........ ......10 feet.		
Further ascent to White Iron lake (estimated) ....20 feet.		
Ascent by portage from White Iron lake to the river in sec. 19, 62-11.........25 feet.		Above Fall lake 115 feet.

The water passing here is about the same as that at the outlet of Vermilion lake.

Ascent by rapids to Birch lake, in sec. 6, 61-11 (estimated)	15 ft.	
Birch lake above Fall lake.............................		130 ft.
Ascent by rapids, in the East Branch of Birch river.		
" N. E. ¼ of sec. 27, 62-11......................	16 ft.	
" S. E. ¼ of sec. 22, 62-11........................	3 ft.	
" S. W. ¼ of sec. 23, 62-11....................	5 ft.	
" N. part of sec. 23, 62-11..........................	5 ft.	
" N. E. ¼ of the S. W. ¼ of sec. 24, 62-11	5 ft.	
" Foot of Copeland's lake....................	6 ft.	40 ft.
Copeland's lake above Fall lake.........		170 ft.
" Head of Copeland's lake, S. E. ¼ sec. 6, 62-10..	8 ft.	
" S. W. ¼ sec. 4, 62-10	1 ft.	
" S. E. ¼ sec. 4, 62-10..........................	8 ft.	
" N. W. ¼ sec. 3, 62-10.........................	3 ft.	
S. E. ¼ sec. 26, 63-10 (Fork of the Kawishiwi)	3 ft.	23 ft.
Fork of the Kawishiwi above Fall lake		193 ft.
Ascent by Archway rapids, sec. 9, 62-10.............	25 ft.	
" Rapids in N. W. ¼ sec. 16, 62-10.........	4 ft.	29 ft.
Gabbro lake, above Fall lake........		222 ft.
Ascent by rapids, S. W. ¼ sec 23, 62-10..............	4 ft.	
Bald Eagle lake above Fall lake........................		226 ft.
Estimated ascent to lake Isabella.....	100 ft.	
Isabella lake above Fall lake............................		326 ft.
Ascent from the fork of the Kawishiwi:		
Rapids S. E. ¼ sec. 24, 63-10............................	6 ft.	
Rapids S. W. ¼ sec 19, 63-9.............................	10 ft.	
Rapids S. E. ¼ sec. 17, 63-9............................	4 ft.	
" N. E. ¼ sec. 20, 63-9............................	9 ft.	
" S. E. ¼ sec. 20, 63-9............................	2 ft.	
" S. E. ¼ sec. 20, 63-9............................	4 ft.	35 ft.

Crab lake above Fall lake		228 ft.
Ascent from Crab lake:		
Rapids in N. E. ¼ sec. 28, 63-9	10 ft.	
Further ascent. Rapids in N. E. ¼ sec. 28, 63-9	10 ft.	
Rapids S. E. ¼ sec. 30, 63-8	8 ft.	
Rapids N. E. ¼ sec 31, 63-8	15 ft.	
Rapids N. W. ¼ sec. 32, 63-8	3 ft.	
Rapids N. W. ¼ sec. 34, 63-8	18 ft.	64 ft.
Wilder lake above Fall lake		292 ft.
Fall lake above lake Superior*	810 ft.	
Lake Superior above the sea	602 ft.	1,412 ft.
Wilder lake above the sea		1,704 ft.
Sec. 3, 63-11. Newton lake below Fall lake, by rapids		10 ft.
Pipestone rapids, Basswood lake below Newton lake		6 ft.
Carp lake above Basswood lake		12 ft.
Cap lake above Carp lake		6 ft.
Ensign lake above Cap lake		1 ft.
Illusion lake above Ensign lake		160 ft.
Ima lake above Illusion lake		20 ft.
Enlargement of the stream entering Ima lake above Ima lake		6 ft.
Small lake just below the outlet of Thomas lake, above the enlargement		12 ft.
Thomas lake above the small lake mentioned		3 ft.
Fraser lake above Thomas lake		1 ft.
Wisini lake above Fraser lake		5 ft.
Syrup lake above Wisini lake		25 ft.
(Wisini and Syrup lakes are in sec. 14, 64-7.)		
Shoe-fly lake above Syrup lake		0 ft.
Lake in the river, sec. 11, 64-7, below Shoe-fly lake		1 ft.
Kekekabic lake below lake in the river		95 ft.
Descent from Kekekabic lake to lake No. 1	4 ft.	
" from lake No. 1 to lake No. 2	25 ft.	
" from lake No. 2 to lake No. 3	15 ft.	
" from lake No. 3 to lake No. 4	2 ft.	
" from lake No. 4 to lake No. 5	12 ft.	58 ft.
Ascent from No. 5 to lake No. 6		18 ft.
Descent from No. 6 to Ogishke Muncie lake		6 ft.
Ogishke Muncie lake below Kekekabic lake		46 ft.

* Ninth annual report, p. 9.

Estimated ascent from Ogishke Muncie lake to Little Reynard lake (an enlargement of the river)........	4 ft.	
Further ascent to Fox lake, S. E. ¼ sec. 26, 65-6	45 ft.	
Ascent (through several little lakes) to Agamok lake........	45 ft.	
Ascent to Gabimichigama lake........	4 ft.	
Gabimichigama lake above Ogishke Muncie lake........		98 ft.
Descent from Kekekabic lake to Pickle lake.....	35 ft.	
" Pickle lake to Spoon lake..........	30 ft.	
" Spoon lake to Doughnut lake......	40 ft.	
" Doughnut lake to Knife lake......	30 ft.	
Knife lake below Kekekabic lake........		135 ft.
Descent from Knife lake to Potato lake..........	18 ft.	
" Potato lake to Seed lake...........	14 ft.	
" Seed lake to Melon lake...........	8 ft.	
" Melon lake to Pseudo messer lake	10 ft.	
" Pseudo-messer lake to Sucker lake	28 ft.	

7. GLACIAL STRIÆ OBSERVED BY N. H. WINCHELL.

	True Meridian.
At the Lee mine, east end of the south ridge on jaspilyte........	S. 10° W.
[Exactly across the general trend of the ridge.]	
At the east end of the south ridge near the top, on jaspilyte........	S. 22° W.
At ¾ mile south of Tower, on graywacke (Jones)......	S. 24° W.
At centre of N. E. ¼ of sec. 3, 61-16 (S. side of Jones bay). Graywacke........	S. 20° W.
At S. E. ¼ of N. E. ¼ sec. 3, 61-16 (near the last). Poroditic graywacke........	S. 18° W.
At centre of sec. 17, 62-15, near W. end of Ely Island. Graywacke........	S. 22° W.
At centre sec. 26, 62-16. Black slate........	S. 20° W.
At S. E. ¼ sec. 9, T. 62-16. Sericitic slate........	S. 22° W.
At corner post of secs. 7, 8, 17 and 18, 62-16. Green schist........	S. 24° W.
At S. W. ¼ of the S. E. ¼ of sec. 19, 62-15. Felsitic conglomerate........	S. 17° W.

	True Meridian.
At S. E. ¼ sec. 5, 62-16. Sericitic rock	S. 19° W.
At S. W. ¼ sec. 6, 62-16. Dark schist	S. 22° W.
At N. E. ¼ sec. 11, 62-17. Hydro-mica schist	S. 28° W.
At N. E. ¼ sec. 32, 63-16. Mica-schist	S. 22° W.
At S. E. ¼ sec. 27, 63-16. Micaceous graywacke	S. 22° W.
At S. E. ¼ sec. 6, 62-15. Graywacke	S. 18° W.
At S. E. ¼ sec. 4, 62-15 (on the island). Graywacke.	S. 20° W.
At centre of sec. 17, 62-15, west end of Ely island. Felsyte	S. 22° W.
At S. E. ¼ S. E. ¼ sec. 17, 62-15, west end of Ely island. Felsyte	S. 22° W.
At S. W. ¼ sec. 17, 62-15, west end of Ely island	S. 18° W.
Centre of sec. 4, 62-15. Graywacke	S. 20° W.
At the east end of Stuntz island. Felsyte	S. 23° W.
S. W. ¼ of sec. 20, 62-15. Graywacke	N. and S.
S. W. ¼ sec. 24, 61-12. Gabbro	S. 12° W.
N. E. ¼ sec. 31, 61-12. Syenite	S. 22° W.
S. E. ¼ sec. 30, 63-8. Gabbro	S. 8° E.
N. E. ¼ sec. 35, 63-9. Gabbro	S. 12° W.
N. W. ¼ sec. 27, 63-10. Gneissic graywacke	S. 15° W.
Sec. 23, 65-10. Northeast cape. Gneiss	S. 15° W.
Sec. 18, 64-7. North shore of Ima lake. Gabbro	S. 36° W.
Sec. 18, 64-7. North shore of Ima lake. Gabbro	S. 23° W.
Sec. 28, 64-7. Island in Thomas lake. Gabbro	S. 25° W.
Sec. 11, 64-7. Gabbro	S. 30° W.
Sec. 29, 65-7. Knife lake. Graywacke	S. 48° W.

6. CATALOGUE OF ROCK SAMPLES COLLECTED BY N. H. WINCHELL IN 1886.

864. Hard schistose rock or graywacke, south side of Jones bay in Vermilion lake, N. E. ¼ of sec. 3, 61-16.

865. Gray quartzyte, from the point near the S. W. ¼ of sec. 34, 62-16.

866. Brown jasper and hematite from the jasper ridge, sec. 29, 62-15.

866 A. Nodules from the above ridge, sec. 29, 62-15.

866 B. Gray fine quartzyte, from S. W. end of the same ridge, 100 feet above Vermilion lake.

867. Lighter colored quartz rock banded with jasper and with hematite, same ridge, sec. 29, 62-15.

868. Massive or basaltiform chloritic syenite, from a low ridge just southeast of last, sec. 32, 62-15.

868 A. Rhomboidal piece showing rough granular weathered surface; same exposed surface.

868 B. Shows the gneissic structure sometimes seen in 868; same locality.

868 C. Quartz from a vein, inclosing green chlorite and having a schistose structure; same exposed surface.

868 D. Contains a piece of chlorite from a fissure and a grain resembling a changed crystal of feldspar; same locality.

868 E. Nearly typical form of 868 obtained south of small ridge, near the west end.

868 F. Gneissic or schistose structure of 868, adjacent to 868 E.

868 G. Sericitic schist, same exposed surface with 868 E.

868 H. Arenaceous sericitic schist, same locality.

868 I. Black slaty jaspilyte, same exposed rock surface.

There is probably an unconformable junction between 868 H and 868 I.

869. Sericitic schist, from S. E. side of same ridge, sec. 32, 62-15.

870. Sericitic or clay slate, graduating into 869, sec. 32, 62-15.

871. Iron ore from the Lee mine, sec. 33, 62-15.

871 A. Crystals of hematite from same locality.

872. Fine-grained doleryte or dike rock, from Stüntz's island, sec. 21, 62-15.

873. Greenish chloritic schist from another set of dikes on same island, sec 21, 62-15.

873 A. Rounded ball of green rock from the schist No. 873 on Stuntz's island.

874. Conglomerate from Stuntz's island, sec. 21, 62-15.

874 A. Pebbles from same conglomerate, same locality.

874 B. Olivinic greenstone, found in 874, near some quartz veins, Stuntz's island, sec. 21, 62-15.

875. Sample of dike in southern part of sec. 12, 62-15.

876. Iron ore from the Tower mine, sec. 27, 62-15.

877. Sample of greenstone dike on Menan island, sec. 36, 63-17.

878. White granite and syenite from dike on Menan island, sec. 36, 63-17.

879. Somewhat firm and gneissic mica-schist, ¼ mile from S. side of sec. 14, 63-17.

880. Lenticular syenitic-like nodules embraced in the mica schist, No. 879, sec. 14, 63-17.

881. Rather fine greenstone, from dike in north part of sec. 35, 63-16.

882. Coarsely schistose greenish rock, from the point projecting northward from sec. 35 into the N. W. ¼ of sec. 36, 63-16.

883. Fissile sericitic schist, N. E. ¼ of sec. 5, 62-15.

884. Cream-white sericitic (?) schist from Breitung mine, sec. 27, 62-15.

885. Sericitic-like rock, ½ mile from railroad cut, S. E. corner of sec. 5, 61-15.

886. Variety of 885 resembling a graywacke, southern end of same cut.

887. Graywacke, S. E. ¼ of sec. 8, 61-15.

888. Graywacke slate from same locality.

889. Pebbly sericitic schist, point, S. E. ¼ of sec. 20, 61-15.

890. Baked schist, from Stone mine, sec. 27, 62-15.

891. Finely banded rock resembling jaspilyte, from the same locality.

892. Rough, scarcely banded jasper, north wall of Stone mine, sec. 27, 62-15.

893. Rigidly slaty jaspilyte, south wall of Stone mine, sec. 27, 62-15.

894. Jaspilyte passing into greenish schist, near railroad cut in Ely mine, sec. 27, 62-15.

895. Transition between the schist and the jaspilyte, without pyrite, same locality as last.

896. Arenaceous schist with rounded (?) grains, railroad cut in Ely mine.

897. Lenticular jaspery and chalcedonic quarzyte, embraced in green schists, Ely mine, sec. 27, 62-15.

898. Two other examples of blending of the schists and jasper, obtained near Tower; exact locality uncertain.

899. Weathered piece of jaspilyte, with crystals of pyrite, obtained near Tower.

900. Same, but containing fine rhombohedra of magnetite, near Tower.

901. Baked clay, near the contact with the jaspilyte; Lee mine, sec. 33, 62-15.

902. Pure red jasper, from the Stone mine.

903. Red jasper, with darker bands of iron ore, Stone mine.

904. Siliceous nodules, from the "baked clay;" Stone mine.

905. Banded specular hematite, Stone mine.

906. Iron ore breccia, same locality.

907. Greenish, finely striped jaspilyte from the Stone mine.

908. Matrix of conglomerate occurring north of the Cady House near Tower.

908 A. Fragments of boulders derived from 908.

909. Hematitic jasper and white or nearly white quartzyte, near Tower, a little to the north.

910. Sericitic schist, from a narrow band between two jasper masses, near Tower.

911. Jasper conglomerate, sec. 20, 62-15.

912. Brecciated schist, cemented by sulphide of iron; Lee mine, sec. 33, 62-15.

913. Graywacke, from low hills S. E. of Tower, near the railroad, sec. 33, 62-15.

914. Porodyte, containing pebbles of graywacke, S. E. of Tower, near the railroad, sec. 33, 62-15.

915. Greenstone, from dike cutting the graywacke near the railroad, S. E. of Tower, sec. 33, 62-15.

916. Breccia, now converted to hematite and a floury white mineral; Breitung mine, sec 27, 62-15.

917. Jaspilyte, from extreme eastern extension of the ridge affording 868; sec. 32, 62-15.

918. Coarse quartz dioryte, from a boulder occurring near the railroad, at Breitung mine.

919. Green schist from the railroad cut south of the Stone mine, sec. 27, 62-15.

920. Graywacke, containing crystalline grains, S. E. ¼ of sec. 6, 62-15.

921. Black or purplish-black clay slate, S. W. ¼ of sec. 6, 62-15; lake shore of Pine island.

922. Fine, tough, granular basaltiform graywacke, shore, S. W. ¼ of sec. 1, 62-16.

923. Samples showing contact of mica-schist and syenite, centre of sec. 35, 63-17.

924. Granite from S. W. ¼ of sec. 35, 63-17.

925. Fine-grained mica schist, same locality.

926. Greenstone, N. E. ¼ of sec. 31, 63-17.

927. Granite, from the point, centre of sec. 23, 63-18.

928. Graywacke-like rock containing syenite in lenticular patches, S. W. corner of sec. 9, 63-17.

929. Mica-schist, not gneissose, N. E. ¼ of sec. 13, 63-18.

930. Gneissic mica-schist from same locality.

931. Reddish-gray gneiss, N. E. ¼ of sec. 13, 63-18.

932. Granite, coarsely crystalline, from the same locality.

933. Gneiss, interstratified in mica-schist, sec. 14, 63-18.

934. Intrusive granite, obtained at mouth of Rice river, so called, N. E. ¼ of sec. 15, 63-18.

935. Granite from a reef in N. W. ¼ of sec. 26, 63-18.

936. Granite somewhat gneissic, from the small island N. W. cor. sec. 32, 63-17.

937. Light-colored granite, from small island just east of Big Island, N. W. ¼ of sec. 22, 62-18.

938. Fine-grained mica-schist, from same small island, west side, N. W. ¼ of sec. 22, 63-18.

939. Green argillyte slate, somewhat crumpled, from the island in S. E. ¼ of sec. 31, 63-16.

940. Reddish granite, coarse, not very common, S. W. ¼ of sec. 23, 63-16. North shore of the bay.

941. Red granite from same place, rather common.

942. Red granite, finer grained than last, composing large bluff, same locality.

943. Red granite, lighter colored than 942, from same bluff.

944. Grayish granite, one of the common phases of the rock of the region, near centre of sec. 23, 63-16.

945. Micaceous gneiss, S. W. ¼ of sec. 23, 63-16.

946. Red micaceous gneiss, from N. E. ¼ of sec. 27, 63-16.

947. Porodyte graywacke, from S. W. ¼ of sec. 3, 62-15.

948. Schist, nodular, and resembling an igneous breccia. "Halt 160," N. W. ¼ sec. 28, 63-11.

949. Green diabase, cutting 948, from same locality.

950. Bedded quartzyte from the Silver City mines, N. E. ¼ sec. 32, 63-11.

951. Quartz in which the tunnel runs, somewhat disintegrated, same locality.

952. Coarse, red-weathering syenite, west side of White Iron lake, sec. 6, 62-11.

953. Coarse porphyritic syenite, river bank, sec. 19, 62-11.

954. Coarse gabbro, east side of Birch lake, on N. W. ¼ sec. 17, 61-11.

955. Granite, dark-colored and gneissic, N. W. ¼ of sec. 26, 61-12. From boulders.

956. Gneissic chlorite rock, containing feldspar and quartz, N. W. ¼ of sec. 26, 61-12. From boulders.

957. Altered olivine rock, same locality. From boulders.

958. Breccia of mica-schist cemented by granite, N. E. ¼ of sec. 21, 61 12.

958 A. Sample of the mica-schist last mentioned.

958 B. Shows the nature and actual width of one of the granite veins occurring in 958, from same locality.

959. Red-weathering bedded granite, bluff on shore of the lake, near ¼ sec. line, sec. 23, 61-12.

960. Ferruginous olivine rock, from a low ridge about 15 rods from shore, S. W. ¼ of sec. 24, 61-12.

961. Shows the contact between syenite 953 and the granite 955 and 957; from last mentioned locality.

962. Olivinitic gabbro, dark-colored, from about ¼ mile west of last.

963. Fine-grained red syenite, like the "red rock" of Grand Marais, near the point at the sec. line between secs. 23 and 24, 61-12.

964. Coarse porphyritic syenite, point on the coast, S. E. ¼ of sec. 22, 61-12.

964 A. Fine granular granite, from vein cutting across 964 and blending below with 965; same locality.

964 A. Mica-schist, in small patches, a phase of 964 A, same locality.

965. Fine-grained granite in regular beds, S. E. ¼ of sec. 22. 61-12.

965 A. Coarse syenite from zigzag vein (or dike) in 965.

966. Coarse syenite below 964 to 965 A inclusive, from same locality.

967. Fragment of dike-like rock cutting coarse syenite, from the bay, N. side of sec. 21, 61-12.

968. Coarse syenite, cut by vein of reddish fine syenite, short distance north of last, beyond N. line of sec. 21, 61-12.

969. Portion of dark vein crossing coarse syenite, S. E. ¼ of sec. 29, 61.12.

970. Fragment from same dike, or vein, showing tendency to become mica-schist; from same locality.

971. Portion of same dike, showing contact with the syenite, and here being, apparently, a true mica-schist; S. E. ¼ of sec. 29, 61-12.

972. Gneiss, sometimes passing into a fine-grained quartzose granite; from a little north of last locality, in same section.

973. Hornblendic gneiss, a phase of 972, from N. W. corner of sec. 30, 61-12.

974. Shows the same rock (972) undergoing a change toward mica-schist; from same locality.

975. Two other examples of 972, here a mottled schist from extreme west end of Birch lake, south of mouth of Birch river.

976. Olivinitic iron ore, from a boulder ¼ mile south of second crossing, S. W. ¼ sec. 10, 62-12.

977. Fine-grained olivine gabbro, from the second crossing Dunka river, S. W. ¼ sec. 10, 60-12.

978. Dioryte apparently passing into coarse red-weathering syenite, S. E. ¼ sec. 28, 61-12.

979. Fine syenite, taken from the Palisade rock of Archway rapids, sec. 9, 62-10.

980. Diabase-felsyte, from a small island in S. E. ¼ of N. W. ¼ sec. 19, 63-9.

981. Hard quartzose gneiss, from an island lying southeast from the last.

982. Biotite-olivine-gabbro, or biotite mica-schist, N. E. ends of little N. E. and S. W. lakes, secs. 15 and 16, 63-9.

983. Undecayed sample of the above. A phase of the real gabbro; same locality.

984. Quartzose gneiss, also a phase of the real gabbro; same locality.

985. Fine-grained gabbro with small percentage of biotite, near the river, S. W. ¼ sec. 16, 63-9.

986. Fine quartzose gneiss or mica-schist, north side of the river, N. W. ¼ sec. 20, 63-9.

987. Fine-grained diabase, from the hill in sec. 18, 63-9.

988. Gabbro, from the summit of a small ridge between the above hill and the shore, sec. 18, 63-9.

989. Fine-grained, slightly micaceous quartzose rock, N. W. ¼ sec. 27, 63-10.

990. Nearly white gneissic rock, shore of lake, north of last, N. W. ¼ sec. 27, 63-10.

991. Gray, red-weathering gneissic rock, from an island in the lake, N. W. ¼ of sec. 27, 63-10.

992. Red-weathering chloritic syenite, north shore of the lake, a little east of 991, N. W. ¼ of sec. 27, 63-10.

993. Chloritic syenite similar to 992, but closely and lenticularly jointed, N. W. ¼ sec. 27, 63-10.

994. Fine red syenite, broken in every direction, from the point between the two bays, N. W. ¼ of sec. 26, 63-10.

995. Hornblendic gneiss, from the second rapids, N. part of sec. 8, 63-10.

996. Igneous rock with a twisted and lenticular gneissic structure, from the hill-range just north of the foot of the portage, S. W. ¼ sec. 21, 63-10.

997. Chloritic syenite like 993, from north side of river near the rapids, N. part of sec. 29, 63-10.

998. Same as 997, obtained about half way up to Garden lake, in the rapids.

999. Same as 997, still further up the rapids, near the shore of Garden lake.

1000. Magnetic quartz schist, from the upper end of the rapids.

1001. Iron ore from Harvey's test-pits, S. E. ¼ of sec. 27, 63-12.

1002. Fine-grained gray siliceous felsitic rock, south shore of Long lake, sec. 28, 63-12.

1003. Slaty or schistose graywacke, half way from the lake shore to Patterson's trenches, sec. 28, 63-12.

1004. Confused sericitic schist, fissile lenticularly, bluff, centre of sec. 19, 63-11.

1005. From the same bluff but overlying 1004, resembling the rock of Kawasachong falls.

1006. Hardened sericitic schist, near contact with dike, N. E. ¼ of sec. 19, 63-11.

1007. Granular quartz with disseminated pyrite, got in contact with 1006.

1008. Obtained two feet from the dike above mentioned, on the south side.

1009. Sample of the dike rock.

1010. Represents the contact of 1008 and 1009.

1011. Essentially the Kawasachong falls rock, at various places between the lake shore and the hill in S. E. ¼ of sec. 19, 63-11.

1012. Black, banded, magnetic quartz schist, from boulders top of hill, S. E. ¼ of sec. 19, 63-11.

1013. Chalcedonic granular quartz, from veins in quartz schist, top of hill, S. E. ¼ of sec. 19, 63-11.

1014. Greenish-gray rock, apparently a modified graywacke, just south of line between secs. 19 and 30, west of trail, 63-11.

1015. Fine brecciated graywacke, rough in general outward aspect, N. E. ¼ of sec. 30, 63-11.

1016. Jasper hematite, centre of sec. 30, 63-11.

1017. Green schist with crystals of white triclinic feldspar and some granular quartz. N. W ¼ of sec. 28, 63-11.

1018. Similar schist on the same exposed surface, but without feldspar.

1019. Similar schist, less schistose. Same exposed surface.

1020. Similar rock, hardly schistose. Same exposed surface.

1021. Similar rock, but evidently changed from an igneous rock. Same exposed surface.

1022. Changed doleryte. Same exposed surface.

1023. Firm massive rock from midst of schists above mentioned, preserving in some places the original structure.

1024. Somewhat schistose magnetic iron ore, from Julian Bausman's, S. W. ¼ of sec. 23, 63-11.

1025. Magnetic iron ore, same locality, brought by Mr. Byrne.

1025 A. Poroditic and apparently overlying 1025, sec. 21, 63-11.

1026. Tremolitic schist, from the island crossed by the section line between 11 and 12, 64-11.

1027. Syenite, from an island in the lake, in sec. 1, 64-11, cut by an apparent dike of mica-schist.

1028. Micaceous rock, containing a thin (syenite?) vein or dike. Same locality. From the left of the contact.

1029. Less micaceous rock, obtained about a foot from the left of the last.

1030. Specimen obtained about three feet further from the left of the contact.

1031. Specimen obtained about 15 feet from the contact.

1032. Fine-grained, red-weathering syenite, gray within, often gneissic and jointed, sec. 23, 65-10.

1033. Micaceous (quartzose?) gneiss, from bands cutting the rock represented by sample 1032.

1034. Coarse vein rock containing the same minerals as 1032 in larger crystals, sec. 23, 65-10.

1035. Fine-grained, dark-gray rock, in some places apparently schistose, east end of portage from Ensign to Illusion lake, sec. 13, 64-8.

1036. Fine-grained (arenaceous?) rock, similar to 1035, Illusion lake, sec. 13, 64-8.

1037. "Muscovado" gabbro, finely granular, gray or yellowish, east side of Illusion lake, sec. 13, 64-8.

1038. Coarse gabbro, from the shore further south, sec. 13, 64-8. Shown on a small island.

1039. Biotitic gneiss, showing a contorted structure, first island south of last, sec. 13, 64-8.

1040. Ferriferous, olivinitic gabbro, little west of meander corner of secs. 28 and 29, N. E. ¼ of sec. 29, 64-7.

1041. Ferriferous gabbro, old mining place on Frazer lake, near the section line between 23 and 24, 64-7.

1042. Gneissic, biotitic gabbro, sometimes apparently quartzose, from the lake in the river, sec. 11, 64-7.

1043. Greenish amphibolitic rock, like that of the ridge south of S. E. part of Kekekabic lake.

1044. Gneissic (syenitic?) rock, south shore of the little gulf at the S. E. side of Kekekabic lake, sec. 11, 64-7.

1045. Thin-bedded gneissic (syenitic?) rock similar to 1044, but weathering reddish, south shore of Kekekabic lake, near the meander corner of sec. line bet. secs. 2 and 3, 64-7.

1046. Purplish-red, syenitic (?) sub-crystalline rock, from a small island near centre of sec. 3, 64-7.

1047. Fine-grained gabbro-like rock, much like 1035, inclosing 1048; S. W. corner Kekekabic lake, S. W. ¼ of sec. 3, 64-7.

1048. Rock composed of rounded and sub-angular masses apparently shading into 1047; S. W. ¼ of sec. 3, 64-7.

1049. Biotite gabbro, somewhat pebbly, bluff 6 feet above the lake, E. side of sec. 4, 64-7.

1050. From the same bluff, near the top.

1051. Orthoclase gabbro, west shore of lake, sec. 3, 64-7.

1052. Red rock, same as 1046, from near contact with 1051, on the point, at W. ½ of sec. 3, 64-7.

1053. Black petrosiliceous rock, distinctly bedded, sometimes slaty, sometimes black slate, N. W. ¼ of sec. 3, 64-7.

1054. Scales showing weathered surface of 1053.

1055. Lenticularly and coarsely schistose greenish schist, N. W. extension of 1049 and 1050, N. W. end of bay projecting northward into sec. 34, 65-7.

1056. Quartz and pinkish orthoclase, from seams in the schist 1055.

1057. Variety of 1055, non-schistose, near the meander corner between secs 35 and 36, 65-7.

1058. Two samples, one conglomeritic and the other a

hard coarse-jointed sometimes schistose rock; from the hill in N. W. ¼ of sec. 36, 65-7.

1059. Another phase of the same rock, non-schistose and coarse-jointed, N. E. ¼ sec. 36, 65-7.

1060. Gneissic mica-schist, apparently an extension of 1055, N. W. ¼ sec. 31, 65-6.

1061. Porphyry, from the east end of the narrows, N. W. ¼ sec. 31, 65-6.

1061 A. Green pebbles from 1061, same locality.

1061 B. Weathered surface of the porphyry, showing free quartz, ditto.

1062. Porphyritic conglomerate, near the narrows in lake No. 6, sec. 28, 65-6.

1062 A. Scale of 1062 coated with twinned crystals of feldspar.

1063. Conglomeritic quartzyte, often like graywacke in aspect, N. W. ¼ of sec. 27, 65-6. N. W. shore of the long bay from Ogishke Muncie lake.

1064. Conglomerate representing the general character of the rock about the bay last mentioned.

1065. Porphyritic conglomerate, from same locality.

1066. Gray quartzyte, sometimes pebbly, generally with no signs of bedding; narrows of bay, N. W. ¼ of sec. 27, 65-6.

1067. Schistose, almost fissile conglomerate, E. side of second narrows of Ogishke Muncie lake, N. W. ¼ of sec. 24, 65-6.

1068. Doleryte, from the hill a little north of the second narrows, east side, sec. 24, 65-6.

1069. Irony conglomerate, hill just northwest of the last, sec. 24, 65-6.

1070. Pebbly schistose conglomerate, from the rapids of the stream connecting Muncie and Town Line lakes, sec. 13, 65-4.

1071. Porphyritic greenish rock, the crystals being of a pyroxenic mineral apparently, northward projecting point, S. shore Frog-rock lake, sec. 18, 65-5.

1072. Green doleryte, from the east end of Frog-rock lake, sec. 17, 65-5.

1073. Coarse-jointed massive rock, apparently igneous, mouth of Ogishke Muncie creek, sec. 26, 65-6.

1074. Irregular stratum of 1073 holding fragments of fissile closely jointed baked slate, sec. 26, 65-6.

1075. Specimen showing the junction of 1073 and 1074 with a blending of characters, sec. 26, 65-6.

1076. Tough massive or coarse-jointed greenstone, from hills in southern part of sec. 35, 65-6.

1077. Pebbly greenstone graduating into 1076.

1078. Coarse-jointed massive rock like 1073 but porphyritic, sec. 35, 65-6.

1079. Matrix of the Ogishke conglomerate, one-third mile from the shore north of Campers' island, southern portion of sec. 23, 65-6.

1079 A. Pebbles from the same.

1080. Porphyritic conglomerate, N. E. corner of S. E. ¼ of sec. 22, 65-6.

1081. Siliceous black slate, N. E. ¼ of sec. 22, 65-6.

1082. Same as 1081 but thick-bedded and arenaceous, sometimes greenish, 80 rods N. W. of last, sec. 22, 65-6.

1083. Green-black so-called slate, resembling diabase, intersecting 1082, from hill, same locality.

1084. Fragmental rock from the dark-green beds represented by 1082, sec. 22, 65-6.

1085. Conglomerate from west side of Little Reynard lake, near the water, sec. 26, 65-6.

1086. Altered black slate, almost igneous-massive in appearance; N. W. side of Fox lake, S. E. ¼ sec. 26, 65-6.

1087. Cherty breccia from the beds shown on the portage between Fox and Agamok lakes, sec. 36, 65-6.

1088. Quartzyte slate, basaltic in aspect, N. shore of Gabimichigama lake, S. W. ¼ sec 29, 65-5.

1089. Hardened, fragmental siliceous rock in heavy layers, Gabimichigama lake, north side of long point, S. W. ¼ of sec. 32, 65-5.

1090. Siliceous biotitic gneiss, sometimes chrysolitic, from south shore of above point, sec. 32, 65-5.

1090 A. Fragment, apparently, of a boulder in 1090, same locality as last.

1091. Biotitic gneiss, without bedding, N. W. portion of S. W. ¼ sec. 32, 65-5.

1092. Stratified biotitic gneiss, showing sedimentary banding, N. W. corner S. W. ¼ of sec. 32, 65-5.

1093. Greenish, nearly homogeneous basaltiform rock, from the point in Kekekabic lake, S. E. side of sec. 29, 65-6.

1094. Porphyritic rock, representing an altered conglomerate, point corners of secs. 29, 30, 31 and 32, 65-6.

1095. Banded graywacke and slate, Mallmann's peak, S. E. ¼ sec. 30, 65-6.

1096. Rock of a dike making a couple of islands in Kekekabic lake, south of Mallmann's peak, N. W. ¼ sec. 31, 65-6.

1097. Chloritic schist with contorted sedimentary structure, shore of Kekekabic lake, S. E. ¼ sec. 30, 65-6.

1098. Conglomeritic chlorite schist, N. W. ¼ of sec. 31, 65-6; phase of 1060.

1099. Homogeneously micaceous rock sometimes gneissic, and conglomeritic variety of same; portage trail from Kekekabic lake northward, sec. 34, 65-7.

1100. Reddish syenite, with lenticularly schistose jointage, most westerly island in Kekekabic lake, sec. 3, 64-7.

1101. Greenish syenite, north side of same island, slightly further west, sec. 3, 64-7.

1102. Greenish syenite identical with 1101, west end of Animikie island, sec. 3, 64-7.

1103. Two samples from N. W. corner Animikie island, showing variations in the metamorphic change; sec. 3, 64-7.

1104. Diabasic rock, east end of same island, sec. 3, 64-7.

1105.–1106. Two samples of porphyritic rock from the little island N. E. of Animikie island, obtained a short distance from each other. on the north side, and showing many important features; sec. 2, 64-7.

1107. Light-weathering black or purplish flint, from the graywacke slates, north of the portage landing on Knife lake, W. side of sec. 27, 65-7.

1108. Mica-schist with bands and veins of syenite, west end of the portage, sec. 6, 64-10.

1109. Sericitic or felsytic schist, at the portage from Newton lake to Fall lake, N. W. ¼ sec. 3, 63-11.

SPECIMENS COLLECTED BY DR. WADSWORTH.

1110. Granite, from the island in White Iron lake, lying in sec. 33, 63-11 and sec. 5, 62-11.

1111.–1115. Schist of several kinds, some of it quartzose, some hornblendic and some micaceous or ferruginous, from the foot of White Iron lake near the northern end.

1116. Granite, same as that of the island (1110), obtained some distance from its contact with the schist, east shore of White Iron lake.

1117.
1118.
1119.
1120.
1121.
1122. Junction specimens of the granite and schist, all, with the exception of 1122, taken from a point part way up the cliff, north end of White Iron lake.

1123.
1124. Portions of the above schist more indurated and altered by contact with the granite, from a point lower down on the cliff.

1125. Portion of same schist cut by two granitic veins; near the lower contact (1123).

1126. Portion of the edge of the granite at the contact, filled with fragments of schist.

1127. Specimen of contorted schist containing magnetite.

1128. Gabbro, cut by intrusive granite, E. shore of White Iron lake.

1129. Intrusive granite as above.

1130.
1131. Specimens showing contact of a dike of the above granite, with the gabbro through which it is intruded.

1132. Black hornblendic gneiss, south of the meander line between secs. 6 and 7, 62-11.

1133. Micro-granite, from dikes cutting granite; meander line between secs. 6 and 7, 62-11.

1134. Micaceous gabbro, cut by veins of granite, from the lake shore in sec. 12, 62-12.

1135. Dark hornblendic rock, from small dikes cutting the granite veins above mentioned.

1136. Gabbro, containing considerable feldspar, from a point about half a mile west of the line between sec. 31, 62-11 and sec. 6, 61-11 in T. 61.

1137. Fine-grained gabbro, looking like diabase, from a point a short distance west of the meander stakes, between secs. 24 and 25, 61-12.

1138. Apparently an indurated schist or sandstone containing much magnetite, from a point just beyond the last.

1139. Granite, containing porphyritic crystals of feldspar, from a point just west of the meander corner between secs. 23 and 24, 61-12.

1140. Granite, fine-grained in texture like a micro-granite, about ¼ of a mile west of the corner above given.

IV.

NOTES OF RECONNOISSANCES.—BY H. V. WINCHELL.

IV.

PARTIAL REPORT OF OBSERVATIONS MADE BY H. V. WINCHELL.

I. NOTES TAKEN AUGUST 26TH, 1886, ON A TRIP FROM FALL LAKE (T. 63, 11) TO LONG LAKE (T. 63, 12) AND ON THE HILLS NORTH OF LONG LAKE.

Long lake and Fall lake (Kawasachong lake) are connected by a stream of considerable size which falls 63 feet between the two lakes.

There are many little falls and rapids on the stream; but the only rock seen in the bed of the stream after passing the first rapids, is in loose pieces and boulders.

On the southeast side of the river near the line between ranges 11 and 12 in secs. 19 and 24, is a low range of rock hills. They are composed of light-colored hydro-mica-schist, finely siliceous and containing numerous small cubes of pyrite. These hills extend in an easterly direction along the south side of Fall lake.

Going up the river from Fall lake the first rapids encountered are over sericitic schist *in situ*. It is exceedingly schistose with the strike 60° E. of N., and with vertical strata. Ten rods further east the strike changes to N. 40° E. No more rock in place can be seen from the river on the way to Long lake.

Crossing to the north side of this lake we find precipitous hill-ranges running in a general direction N. 40° E. and increasing in hight as we cross them — going north, until the upper level is reached at 190 feet above the lake, as measured by the aneroid.

The hills in secs. 22 and 15 are made up chiefly of a fine-grained compact green rock. It is all so firm that there is no appearance of any stratification or schistose structure; but there are curved lines or threads of schistose rock running all through it. The rock in these veins sometimes appears like dioryte and sometimes like sericitic schist. There are crystals of hornblende in it that stand out on the weathered surface and give a darker and rougher appearance to the network of veins which is everywhere seen on the surface of the bare hills.

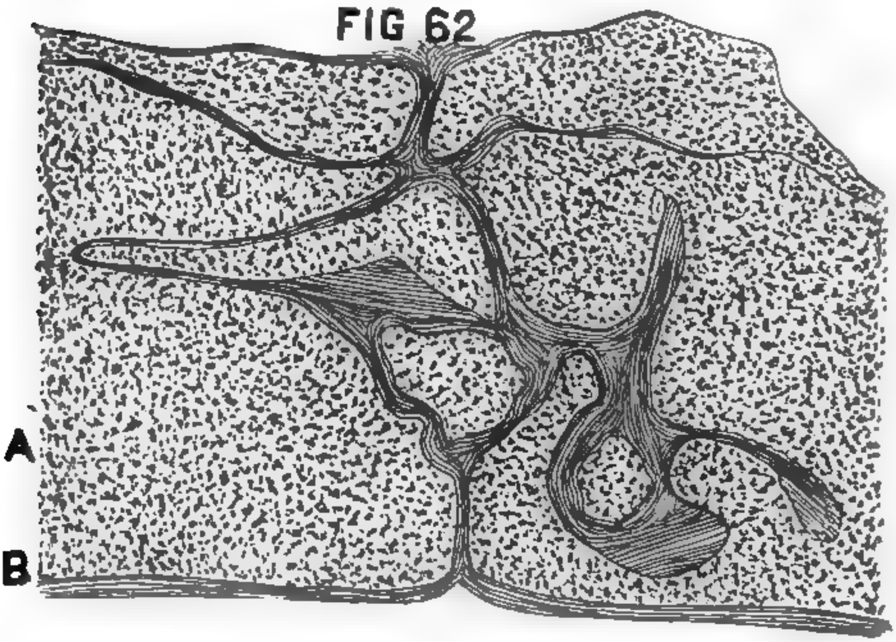

Fig. 62.—*Green schistose veinings in greenstone.*

Going northward through sec. 15, 63-12, the ranges of hills maintain about the same hight. They are precipitous and deep ravines separate them. The rock changes rapidly, becoming more massive and solid in structure as we go north. The hills nearest the lake are a sort of greenish hydro-mica [chloritic?] schist. The next ranges are harder and less changed by weathering, and are finely crystalline in structure like doleryte. The hills beyond these are coarser and look like fine dioryte and so on; the rock becoming coarser and more crystalline in structure toward the north.

Quartz veins are everywhere met with running in all directions and sometimes lying flat upon the surface. The general glaciation is N. 24° E. and the direction of the hill-ranges N. 40° E. The schistose rock seems to dip north and sometimes contains irregular-shaped fragments of the granular quartz such as were seen in the schists north of Tower.

One of the ranges of dioryte, as high above the lake as most of them, has had remarkable action exerted upon it by frost. Water seems to have penetrated the surface of a round knob of this rock and has split it apart to a depth of 20 or 30 feet, moving masses weighing thousands of tons, several feet asunder, and even lifting them up and turning them completely over. Water continually stands at the bottoms of the chasms.

The hills in this locality are nearly bare, have no soil on them, but few bushes and little moss. The opportunity for ascertaining the geology is excellent here, but it is rougher traveling than around the lake shores.

Portions of the rock in the first high range of hills north of the lake contain light greenish amygdules that stand out in little round globules on weathered surfaces.

The rock for the first three-quarters of a mile north of the lake, including the schist near the lake and the semi-crystalline rock further north, contains beds or veins of a very hard siliceous, partially metamorphosed rock which is probably petrosilex. This rock shows stratification both on the surface which weathers white and in the green interior.

The beds stand vertical and extend for an indefinite distance nearly east and west through the other rock. The general thickness is about six inches; but in some veins it is two or even three feet. An indistinct tendency to coarse crystallization was observed in these veins as if they were homogeneous enough to crystallize like a mineral and not to be made up of various different crystallized minerals like a rock. Some specimens were obtained showing this peculiarity. No. 29 (H).

The general impression obtained of this region is that it is on the boundary line between the purely schistose rocks on the south and the crystalline rocks on the north.

2. NOTES ON BAYS IV, V, III, AND II, BASSWOOD LAKE, MADE IN THE FIRST TEN DAYS OF SEPTEMBER, 1886.

Bay IV. Starting from the falls in sec 22, 64-11, and going up the left shore, the first observation made was on a small island in the N. W. ¼ of sec. 22. The rock here is a mixture of chlorite (?) and feldspar. The green mineral looks more like hornblende in fresh breaks; but the general appearance is that of chlorite. This rock seems to be massive and unstratified.

Near the south quarter-post of sec. 15, 64-11, is a bold bluff of greenish schist 25 feet above the water. The rock is composed of fine mica (partly hydrous), feldspar. and some chlorite or hornblende. It is very schistose; strike is N. 40° E., dip is S. W., at an angle of 85°. White feldspar stands out on the surface. In some places the rock is semi-crystalline and resembles dioryte, No. 30 (H). A quarter of a mile further northeast is a high bluff of micaceous chloritic schist. The hills rise 50-75 feet above the lake. Dip is 65° to the S. W. Eighty rods further on is a greenish, micaceous hornblendic schist containing a little feldspar. The rock changes rapidly in the direction of the strike and becomes less schistose. See Nos. 31 (H) 31 A (H) and 31 B (H.)

The schist contains disseminated nodules and lumps of iron ore schist.

Going northeast across the strike the rock becomes less schistose and contains gradually more feldspar and a green mineral, probably epidote. It finally passes into a rock composed almost entirely of feldspar and this green mineral. The other ingredients are a little mica and hornblende. It is very noticeable that as the schist changes into a more massive rock and the schistose structure disappears, a "stratification" is shown by a regular arrangement of the minerals in bands or layers having the same direction as the strike of the schist. No. 32 (H) shows this arrangement of the minerals. A little further along the rock is more coarsely crystalline and more largely feldspathic, also containing irregular-shaped patches of dioryte. See No. 33 (H).

The long point in the S. E. ¼ sec. 11, same township, is composed of layers of schist and dike-like beds running in a direction W. 10° S. Some of the beds of schist are very micaceous with muscovite and some are very siliceous. There are other variations in composition making the rock a queer mixture taken altogether. The dikes are diabasic and are well defined. They

cut the beds of schist very little, if at all. The dip of the schist is 80° to S. W.

A little further around the point the strike changes to west. Glaciation is N. 22° E.

The point in the N. W. ¼ of S. E. ¼ sec. 11, is composed of fine-grained mica-schist, dipping at an angle of 65° to the S. W.

On the point in the W. ½ of sec. 11 we find for the first time syenite mixing with the mica-schist. It very rapidly interbeds with it until the beds alternate with a thickness of from half an inch to three or four inches. Just before coming to this mixture of syenite and schist, were passed a few feet of greenish looking rock somewhat felsitic. See No. 34 (H). The strike of these beds is W. 24° S. See Fig. 63 for illustration of this place.

FIG 63

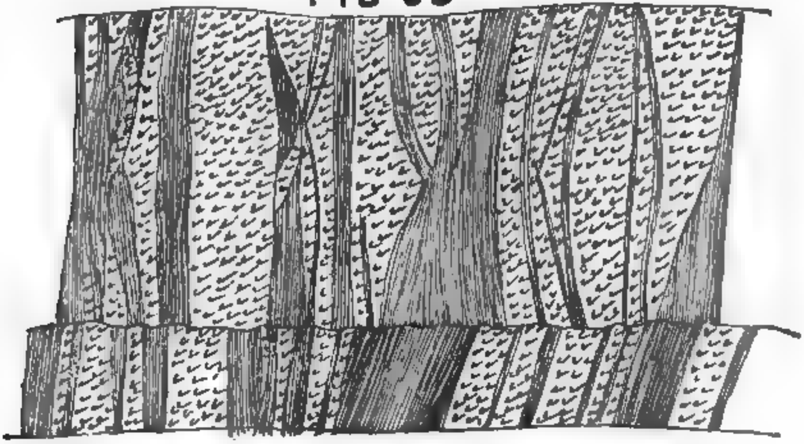

Fig. 63.— *Fault cutting interbedded syenite and schist.*

In the N. E. ¼ of sec. 11 is a bed of pinkish gneiss dipping S. at an angle of only about 15°. It is ten rods across and at the E. side of it is a coarse-grained syenite-gneiss standing nearly vertical. See Nos. 36 (H) and 37 (H). Some of the beds are hornblendic and some are almost wholly feldspar and quartz. This nearly flat-bedded syenite-gneiss continues for a quarter of a mile or more and there are frequent places where the jointage structure gives it the appearance of being in vertical beds.

Beds of syenite gneiss continue around the west shore of this bay for some distance; sometimes the gneiss contains small scales of biotite. In the S. E. ¼ of S. E. ¼ of sec. 2, 64-11, it is cut by beds

of pink syenite running E and W. There is the same apparent low angled dip, but the dike-like beds stand nearly vertical. It is noticeable that each bed seems to be much more massive on the E. or S. side than on the upper or N. W. side where it has a gneissoid structure. A few rods further on there is a bold bluff of pink gneiss, 15 feet high, very gneissic and standing apparently on edge, with the strike nearly N. and S.

The point in the S. E. ¼ of sec. 2 is composed, on the west side, of syenite. This gradually changes to a greenish siliceo-feldspathic rock like felsyte; and this grades into mica-schist. It does not remain long in that condition but passes back into a reddish-green rock that looks like syenite on the surface; but which seems to be only a mixture of syenite and schist. Strike is N. 70° E. See Nos. 38 (H), 38 A (H) and 38 B (H). A little further east the bluffs of syenite are higher and more quartzose. They contain also hornblende schist running in direction 10° S. of E. through the rock. These beds of hornblende schist vary in thickness from an inch to four or five feet.

Micaceous syenite-gneiss is found in N. W. ¼ of sec. 6, 64-10. Beds of hornblende schist are inclosed in this gneiss. The hornblende, however, often changes to mica and much quartz is present. On a small island near the shore at the N. W. corner of 64-10 is a display of perfectly interstratified schist and gneiss. The beds run N. 70° E. dip *north* 65° and alternate between hornblende-schist containing mica and syenitic gneiss with a little mica. It is one of the finest exposures to be seen in this region.

Bay V. The point in the S. ½ of sec. 36, 65-11, is a high bluff of syenite-gneiss containing beds of hornblende-schist. The general strike is N. 75° E. This bluff is rounded and bare and almost 50 feet high.

In the centre of sec. 2, 64-11, the syenite-gneiss again seems to dip north at an angle of 15° or 20°. It is thick-bedded and immense quantities are to be seen on all sides.

In the S. W. ¼ of sec. 2, 64-11, syenite-gneiss occurs interstratified with thin beds of mica and hornblende schists. The dip is N. 15° or 20°. There is a very large exposure at this place. The beds are cut by dikes or beds of syenite. See No. 45 (H). The rock in the N. E. ¼ sec. 10, 64-11, is gneiss, containing mica-schist interbedded with it; both being cut by syenite beds. It is coarsely crystalline in spots, the feldspar crystal being over half an inch long.

On the north side of the west end of the bay in sec. 8, 64-11, is a mixed exposure of syenitic gneiss and hornblendic schist. Beds or dikes of syenite run in all directions through and across the schist, inclosing and cutting it into all manner of shapes. Dip is N. 15°. See Nos. 47 (H), 48 (H). In the N. W. ¼ sec. 9, 64-11, there is a high ridge of syenite or dioryte interbedded with hornblende schist. It rises fifty feet above the lake and where it comes out to the lake shore it forms a huge bluff, the dip being north at angles varying from 15° to 60°. Strike is N. 60° E. Near the intersection of the shore line with the east line of sec. 4, 64-11, the syenite again crops out. Here there are thick beds of granite or gneiss and thin beds of mica-schist. The beds stand nearly vertical but have a slight inclination to the north. Strike is N. 70° E. See No. 49 (H). All the way across the east end of the long point in the N. ½ of sec. 3, 64-11, is a fine display of mica-schist and gneiss, interstratified in thin beds and dipping north 60°. General strike is N. 74° E. Nos. 50 (H) and 51 (H) are samples of this rock. Interstratified gneiss and mica-schist are again seen on the line between secs. 35 and 36, 65-11. They dip north 60° and the strike is N. 70° E. It is noticeable that the mica is coarser near the contact with gneiss than in the beds of mica-schist.

The long point in the N. E. ¼ of sec. 36, 65-11, is a high bluff of interbedded gneiss and mica-schist. It rises 50 feet above the lake. Dip is N. 70°. Strike is N. 70°: E.

BASSWOOD LAKE.

Bay III. Gneiss containing some hornblende is found on a low point in the N. E. ¼ of sec. 3, 64-10. It is thin bedded, 13 beds in a thickness of two feet being counted in one spot. It seems to dip south at a low angle. There are dikes cutting the beds in various directions. These dikes are very siliceous, being composed almost wholly of quartz and feldspar with a little mica. The quartz seems to be granular and not massive. See Nos. 52 (H) and 53 (H). A few rods further on there is some schist interbedded with the gneiss. In some places this schist is mostly hornblendic; in others quite micaceous.

Near the line between secs. 3 and 4, 64-10, is a bluff of dioryte (?). It rises ten or twelve feet above the water and shows no signs of gneissoid structure. The hornblende crystals are sometimes over an inch long. No. 34 (H).

This dioryte continues for several rods along the shore to the west. It suddenly comes into contact with gneiss and mica schist. The direction of the line of contact is E. 2° S. Crossing this bed of mica-schist we come to another bed of dioryte, then to a bed of mica-schist or hornblende-schist again and so on until it seems as if they were interbedded; though the dioryte appears to lie upon the other rocks a little as though it had flowed over them. The schists stand on edge (?) and run in the direction of the contact with the dioryte. There are also dikes of gneiss cutting the dioryte. Nos. 55 (H) and 56 (H). Near the west line of sec. 4, 64-10, is a ridge of syenitic gneiss which grades by imperceptible changes into schist. Dip is N. 60. Strike is N. 50° E.

The micaceous, hornblendic schist is somewhat siliceous and probably contains some feldspar. Gradually, in the space of a few inches along the strike, it acquires more and more quartz and feldspar until it becomes reddish syenite gneiss. Thus we have mica and hornblende schists changing to gneiss and syenite-gneiss, not only by being more and more finely interbedded, but also by a mixture of the minerals of which each rock is composed. Nos. 57 (H), 57 A (H), 57 B (H), 57 C (H) and 57 D (H), illustrate this transition.

On ahe west side of the portage in sec. 5, 64-10, is found mica-schist with considerable feldspar and quartz; also a porphyritic syenite-gneiss containing sometimes much mica. The feldspar crystals are white and stand out on weathered surfaces. Dip S. 85°.

Near the west line of sec. 5, 64-10, is a bed of rock resembling dioryte but containing biotite. It is coarsely crystalline and seems to dip south and under the syenite a little further west. See No. 59 (H).

There is a low outcrop of rock resembling diabase, very siliceous, in the S. E. ¼ of sec. 6, 64-10. It has no distinct bedding or schistose structure. Glaciation is N. 22° E. The point in the S. W. ¼ of sec. 5, same township, is made up of very fine mica-schist. It is in long smooth beds dipping south 80° or 85°. The strike is N. 60° E. This schist would make fine scythe stones. Only one bed of gneiss was seen on this point; it was a foot thick and about six feet long in the direction of the strike of the schist. It was completly inclosed by the schist and was very micaceous itself.

In the S. E. ¼ of the N. W. ¼ of sec. 16, 64-10, is mica-schist

in uneven wavy beds, dipping north at angles varying from 20° to 50°. Strike is E. 20° S. The schist seems to be an intermediate stage between gneiss and schist. Feldspar crystals stand out on weathered surfaces and give a whitish appearance to the rock. This schist is ferruginous and disturbs the compass. A little further up on the knoll the dip is south and the strike is E. 60° S. So this point is probably not as indicative of a general northern dip to the rocks of this locality.

3. PSEUDO-MESSER LAKE.

The bluffs around the west end of this lake are quite precipitous and heavily wooded. The rocks are quite different from those of the Basswood lake region; being apparently of the same character as the Vermilion lake rocks.

The general condition of the rock is an argillitic slate or schist varying to a siliceous graywacke that resembles diabase. Dip is south at a high angle and general trend is N. 70° E. There is much pyrite in small cubes, which have a greenish color scattered through the slate. There also appears a white mineral in many places in cracks and seams; it is perhaps dolomite. A small island in a bay at the south side of the lake presents some interesting features. The rock of which it is composed varies from a fine, homogeneous slate to a solid, coarsely granular rock with a basaltic structure and every appearance of trap. We see here also a grayish quartz-porphyry containing nodules of black jasper. This becomes finer and finer until it grades into a light greenish aphanyte. The rock on this island resembles very much that on the island at the mouth of Stuntz bay, Vermilion lake. There is a similar high range of hills just south of it too that suggests the iron range at Tower.

Knife lake. The hills at the west end of the lake are from 20 feet to 60 feet high, covered with small poplar, birch and cedar trees; while here and there are a few large pines, which having escaped the fires are left standing. The rock is very fine-grained siliceous slate, bluish-gray to greenish-black.

It is very finely banded in some places and sedimentary structure is very evident. In spots it becomes coarser and contains rounded nodules of vitreous quartz. It stands nearly on edge, dipping south 85° or 88°. The strike is quite uniformly N. 70° E. The slate is found coarse-grained on the east side of the bay in the S. W. ¼ of sec. 1, 65-7.

On a point near the west line of sec. 28, the slate has considerable quartz and pyrite in it.

In the N. E. ¼ of N. E. ¼ of sec. 27, 65-7, is a fine exposure of this flinty slate. The structure of the rock is not amorphous here, but passes into the greenish rock called porodyte seen at Stuntz bay, Vermilion lake.

The rocks and water look very much alike in this and adjoining lakes. Both are clear and have a greenish tint of cleanliness and purity that is refreshing to the eye.

The schistose structure and the bands of sedimentation when visible do not always coincide, sometimes varying one way and sometimes the other. On the point in the S. W. ¼ of sec. 23, 65-7, is a fine exhibition of the banded sedimentary structure. The bands run very nearly straight and uninterrupted across the surface of this knoll for several rods. Strike is N. 72° E. The beds vary in hardness and in color; but they all weather white on the surface. Dip is south 75°.

The rock composing the high bluff in the N. W. ¼ of the S. W. ¼ of sec. 24, 65-7, is very hard and tough with a basaltic structure. It is semi-crystalline, and of a grayish-green color.

In the S. E. ¼ of the same section is a knoll where the rock changes from the flinty slate to a fine conglomerate containing jasper and vitreous quartz, and further to a coarse conglomerate containing pebbles an inch long. This change occurs both in crossing the beds and in following the strike. Strike is E. 48° S. Glaciation is N. 30° E. See Nos. 71 (H), 71 A (H), 71 B (H). In the S. E. ¼ of sec. 19, 65-6, is a ridge of porodyte or felsyte. It is a greenish-gray rock, with green veins running through the white-weathered surface. There is a remarkable change in the strike of the rocks through here, as is indicated by the direction of the coast line. Strike is N. 40° S. There is a coarse schistose structure trending N. 50° E. Perhaps the high ridge of rock just south of this has something to do with it.

5. OGISHKE MUNCIE LAKE.

Going south from the lake through secs. 26 and 35, the first rock passed over is conglomerate, comparatively even bedded and undisturbed. Then the bedding begins to be broken and the strike and dip change very noticeably. Sometimes the strike and schistose structure are both N. 50° E., and dip south; sometimes the bedding trends from N. W. to S. E., the

schistose structure is N. E. and S. W., and the dip is west. The pebbles too become smaller and the rock is more metamorphosed. Frequently it is porodyte and just as often it is the fine siliceous slate, such as was seen at Knife lake. As soon as the higher hills in sec. 35 are reached this is all changed. No strike or dip or other evidences of sedimentary structure can be seen. It is a massive crystalline rock rising 350 feet above the lake. See. No. 73 (H).

The point crossed by the south line of sec. 23, 65-6, is composed of the stratified quartzyte and conglomerate formation. The beds are parallel and distinct. Dip is south 85°. Strike is N. 60° E. Some of the beds are not very siliceous, but appear to be argillyte; while others are coarse and semi-crystalline and contain small pebbles of quartz and jasper.

In the S. E. ¼ of the S. E. ¼ of sec. 23, 65-6, the rock is greenish and massive with basaltic structure and the general appearance of an igneous rock. It sometimes assumes a reddish or pinkish tinge and looks almost like syenite. Further up the hill, however, in the same hard massive rock are discovered boulders. Of course they are considerably changed from their original condition; but there they are, some as large as six inches in diameter. No. 74 (H) is a sample of this rock.

6. LIST OF SPECIMENS, COLLECTED BY H. V. WINCHELL, DURING THE SUMMER OF 1886.

No. 1 (H). From the point in S. E. ¼ sec. 20, 62-15. A compact semi-metamorphosed rock containing rounded grains of quartz scattered all through it.

No. 2 (H). From the island in the mouth of Stuntz bay, sec. 21, 62-15. A gray felsyte with an indistinct schistose structure and also a basaltic appearance.

No. 2 A (H). Pebbles of a soft greenish rock, perhaps a fine-grained sericite schist, which were contained in No. 2 (H).

No. 2 B (H). From Ely island, S. E. ¼ sec. 17, 62-15. Pebbles of quartzyte, jasper, etc., from the felsitic conglomerate No. 2 (H).

No. 3 (H). Ely island, N. E. ¼ sec. 15, 62-15. A sericitic schist, varying in coarseness from a rock like No. 1 (H) to slate. It seems to grade into the felsitic conglomerate.

No. 4 (H). From the island crossed by the line between secs. 15 and 16, 62-16. Gray sericitic schist; hard, tough, compact and contains pyrite.

No. 5 (H). From the N. W. corner of sec. 17, 62-16. A green homogeneous schist, moderately firm and compact. Has basaltic structure in places.

No. 6 (H). North side of the bay in the S. E. ¼ sec. 7, 62-16. Massive syenite, grayish red to greenish. In bold crags 15 feet above the lake.

No. 7 (H). From a point in S. E. ¼ sec. 8, 62-16. A fine-grained, evenly-bedded siliceous schist. Would make good whetstones.

No. 8 (H). Same locality as last. It is a fine conglomerate(?). The pebbles are feldspathic and quartzose. Color varies from reddish to greenish. The matrix is like sericitic schist.

No. 9 (H). From N. E. ¼ sec. 9, 62-16. Samples from a dike-like bed which appears to cut the sericitic schist, and even seems in one place to have thrown it over from a vertical to a horizontal position; but in another place has an indistinct structure of sedimentaton.

No. 10 (H). West side of point in sec. 5, 62-16. From dikes of rock similar to No. 2 (H), which cut the sericitic schist or stand in beds unconformable with it. Does not contain pebbles as did No. 2 (H).

No. 11 (H). S. E. ¼ sec. 5, 62-16. A tough, grayish-green rock, containing mica and pyrite with quartz-veins. Has also nodules of syenite dispersed through it. Dike runs parallel with the bedding which is east and west; but the schistose structure is N. 20° E.

No. 12 (H). Coarse chloritic mica-schist from the S. side of an island in S. W. ¼ sec. 32, 63-16. It apparently grades into the sericitic schist.

No. 12 A (H). Dike-rock running east and west through No. 12 (H). It is porphyritic and the crystals of feldspar are harder than the matrix or ground-mass of the rock which is schistose. This rock resembles No. 8 (H), the so-called conglomerate. The dikes are six inches to two feet in thickness.

No. 12 B (H). Green schist lying on the north side of the dikes which furnished No. 12 A (H).

No. 13 (H). Fine-grained characteristic mica-schist from S. W. ¼ sec. 31, 63-16. This schist rises 30-40 feet above the lake in hills running N. 26° E. It contains numerous short veins of quartz.

No. 13 A (H) is pink syenite from dikes or beds in the mica-schist last mentioned. The dikes have a general east and west

direction, and vary in color from white to very dark and from two to eight feet in thickness.

No. 13 B (H) is from green trap dikes which run in all directions through the schist at this same place.

No. 13 C (H). A firm, non-schistose grade of No. 13 B (H). It is fine, compact, and of a grayish-green color. It contains the constituents of granite.

No. 14 (H). A heavy, fine-grained schist from S. W. ¼ sec. 6, 62-16. Contains some feldspar, much pyrite and little mica. Some strata seen to contain hematite.

No. 15 (H). Near the township line in N. W. ¼ sec. 7, 62-16. A heavy, massive, greenish-black dioryte (?); probably a dike. It forms an outcrop of 100 feet or more.

No. 16 (H). On the south side of this dike is a bed of porphyritic syenite. It rises in a bold knob 20 feet above the lake. Perfect crystals of feldspar, half an inch long, stand out all over the weathered surface of the rock and can be picked out with little trouble.

No. 17 (H). A greenish siliceous schist with faint bedding and basaltic structure from the point in the S. W. ¼ of S. E. ¼ sec. 1, 62-17, much like No. 14 (H).

No. 18 (H). From a small island in S. E. ¼ of N. E. ¼ sec. 11, 62-17. A hard greenish rock with no apparent bedding; but with a schistose structure running E. 40° S.

No. 19 (H). From a ridge of hard pinkish-green dioryte, or syenite, rising up out of the mica-schist in sec. 3, 62-17. It is very tough and massive and makes hills 90 feet above the lake. There are alternate beds, or ridges, of this rock and mica-schist along the shore in sec. 3 for a considerable distance. The general direction is the same as the schistose structure of the schist, viz.: N. 60° E.

No. 19 A (H). From dike of red syenite cutting the last in N. E. ¼ of N. E. ¼ sec. 3, 62-17. Direction of dike is E. and W.

No. 20 (H). A pink rock that appears to be almost wholly feldspar. It is partially decomposed and has a schistose structure, and grades by imperceptible degrees into the green hydromica schist. It is found on the south side of a small island in the centre of sec. 2, 62-17.

Long lake.

No. 21 (H). Hydromica schist from the first rapids encoun-

tered going up the river from Fall lake to Long lake. Sec. 24, 63-12. It is very schistose and is a fine, soft rock; like slate.

No. 22 (H). Greenish, schistose rock from the top of Sunset peak, half a mile north of the east end of Long lake, 62-12. There are three specimens representing the different aspects of the rock.

No. 23 (H). Specimens of the rock from the veins or twisted beds which are found running all through the hill-tops in the same peak.

Nos. 24 (H), 25 (H), 26 (H), 27 (H) and 28 (H) are specimens taken in that order from the different hill-ranges crossed in going north through sec. 15, 63-12. They exhibit the tendency of the rock to become more crystalline in structure.

No. 29 (H). Four specimens of petrosilex from the beds in the rock within half a mile north of the east end of Long lake. They seem to be imperfect crytals.

Basswood lake.

No. 30 (H). Near the S. quarter-post of sec. 15, 64-11, from a bluff of greenish, micaceous schist varying in hardness, some being almost like fine dioryte.

Nos. 31 (H), 31 A (H) and 31 B (H) are from the N. E. ¼ of sec. 15, 64-11, showing changes from a fine micaceous schist to a hard compact rock with no apparent structure of any kind. The schist contains porphyritic nodules of feldspar and occasionally of quartz.

No. 32. (H). Same locality as last, a little further to the N. E. It is a hard condition of the schist showing the schistose nature by the arrangement of the constituent minerals in regular lines or bands.

No. 33 (H). A little further to the N. E. More coarsely crystalline rock and more feldspathic, containing irregular patches of dioryte.

No. 34 (H). A greenish felsitic rock, met with just before coming to the interstratified mica-schist and syenite in the middle of sec. 11, 64-11.

No. 35 (H). A piece of the syenite which is interstratified with mica-schist in the same locality as last.

No. 36 (H). Pink gneiss from N. E. ¼ of sec. 11, 64-11. It dips south at an angle of 15°. It is 10 rods across.

No. 37 (H) is coarse syenite-gneiss, standing nearly vertical at the east end of last.

Nos. 38 (H), 38 A (H), and 38 B (H) are intermediate grades of rock between syenite and mica-schist. From the point in S. E. ¼ of sec. 2, 64-11.

No. 39 (H). Sample of the felsitic rock on the N. E. side of same point.

No. 40 (H) is a specimen of the hornblende-schist which runs through the syenite in vertical beds of a few inches to five feet in thickness; a little further east than the last.

No. 41 (H). Sample of schist inclosed in gneiss with the hornblende of the schist changing to mica. N. W. ¼ sec. 6, 64-10.

No. 42 (H). Dark hornblendic gneiss from the same locality.

No. 43 (H). Gneiss that appears on the surface like a hard sandstone or stratified quartzyte. From N. W. corner 64-10.

No. 44 (H). Hornblendic gneiss from W. side of the point in S. ½ sec. 36, 65-11. Shows hornblende and mica in a state of confused mixture.

No. 45 (H). Samples of schist interstratified with gneiss from S. W. ¼ sec. 2, 64-11.

No. 46 (H). Coarse gneiss, from N. E. ¼ sec. 10, 64-11. It is interstratified with mica-schist and cut by syenite dikes.

No. 47 (H). Syenite-gneiss, very fine, containing much hornblende. N. E. ¼ sec. 8, 64-11.

No. 48 (H). Hornblende-schist, containing mica. From same locality.

No. 49. (H). Where the east line of sec. 4 enters the bay, is obtained a sample of mica and hornblende-schist inclosing a thin bed of granulyte.

No. 50 (H). Gneiss which is interstratified with mica-schist, on the north side of the point in sec. 3, 64-11.

No. 51 (H.) Sample of the mica-schist from the same place.

No. 52 (H). Gneiss; which is cut by dikes or beds of granulyte in the N. E. ¼ sec. 3, 64-10. Gneiss occurs in very thin beds.

No. 53 (H). Granulyte or dike rock which cuts the last.

No. 54 (H). Dioryte; one sample fine, two very coarse. From W. side sec. 3, 64-10.

No. 55 (H). Schist from same locality as last. This appears to be interstratified with last.

No. 56 (H). Is the gneiss that occurs, interbedded with the schist. Same place as last.

Nos. 57 (H), 57 A (H), 57 B (H), 57 C (H) and 57 D (H) show

a transition from schist to syenite-gneiss by a gradual change in the character of the minerals which compose the rocks.

No. 58 (H). Porphyritic syenite-gneiss. From W. side of the portage in sec. 5, 64-10.

No. 59 (H). Micaceous dioryte from the W. side of sec. 5, 64-10.

No. 60 (H). Siliceous green rock resembling diabase, S. E. ¼ sec. 6, 64-10.

No. 61 (H) is a coarser crystalline rock from the same place. It lies just north of No. 60 (H).

No. 62 (H). Mica-schist intermediate between schist and gneiss, with the mica and feldspar arranged in layers. S. E. ¼ of N. W. ¼ of sec. 16, 64-10.

No. 63 (H). From a locality in Canada on Pseudo-messer lake. One sample is an argillitic slate and one is a semi-crystalline, somewhat siliceous rock, containing much pyrite in cubes.

No. 64 (H). is a quartz porphyry containing granular nodules of glassy quartz and lumps or grains of an opaque white mineral.

Nos. 64 A (H), 64 B (H), 64 C (H), and 64 D (H) are finer and finer grades of the last number, becoming finally a light greenish rock, like felsyte. These specimens are from an island in a small bay on the south side of Pseudo-messer lake.

No. 65 (H) is a specimen showing the transition from the quartzyte to the stratified siliceous argillyte. From same place as last.

No. 66 (H). Argillaceous slate of a dark color, from the centre of sec. 31, 65-7, Knife lake.

No. 67 (H). Is an average specimen of the flinty slate from which the lake takes its name (Knife lake). It is hard, fine-grained, and of a bluish-black color.

No. 68 (H). A specimen of the flinty slate showing how white it becomes on weathered surfaces. From S. W. ¼ sec. 23, 65-7.

No. 69 (H). Grayish-green basaltic rock which forms the high bluff in N. W. ¼ of S. W. ¼ sec. 24, 65-7. Contains much marcasite (?) and is the "gold rock" which caused so much excitement in that region a few years ago.

No. 70 (H) is a semi-crystalline rock which seems to be composed of chlorite, sericite and vitreous quartz. It is from N.W. ¼ of S. E. ¼ sec. 24, 65-7.

Nos. 71 (H), 71 A (H), and 71 B (H) show the change from a

flinty slate to a conglomerate, containing pebbles an inch long. S. E. ¼ sec. 24, 65-7.

No. 72 (H). Finely crystalline greenstone containing vitreous quartz. From N. W. ¼ of S. E. ¼ sec. 20, 65-6.

Ogishke Muncie lake.

No. 73 (H). Gabbro (?). From sec. 35, 65-6, in hills 350 feet high. S. of the lake.

No. 74 (H). Greenstone resembling trap. S. E. ¼ of S. E. ¼ of sec. 23, 65-6, near the top of the hills south of Ogishke Muncie lake.

V.

CHEMISTRY.

REPORT OF PROF. J. A. DODGE

V.

CHEMISTRY.

REPORT OF PROF. J. A. DODGE.

MINNEAPOLIS, May 16, 1887.

Prof. N. H. Winchell,

DEAR SIR: I hereby report to you the results of the chemical analyses made at this laboratory, for the State Geological Survey, since my report of May 27, 1886.

Chemical series	No. 179.	No. 180.	No. 181.	No. 182.
Silica, SiO_2	50.86 per cent.	61.09 per cent.	51.82 per cent.	50.41 per cent.
Alumina, Al_2O_3	15.72 "	15.34 "	13.19 "	13.40 "
Sesquioxide of iron, Fe_2O_3	9.77 "	5.74 "	4.88 "	9.96 "
Protoxide of iron, FeO	2.48 "	3.69 "	6.45 "	9.94 "
Lime, CaO	10.52 "	3.10 "	8.38 "	7.84 "
Magnesia, MgO	3.55 "	1.33 "	5.44 "	1.73 "
Soda, Na_2O	3.89 "	3.41 "	3.21 "	2.47 "
Potash, K_2O	.90 "	3.65 "	2.14 "	1.79 "
Water, H_2O	2.53 "	1.80 "	2.29 "	.87 "
	100.22	99.15	97.80	98.41

	Chem. series No. 183.	No. 184.	No. 185.
Silica, SiO_2	49.65 per cent.	57.09 per cent.	53.43 per cent.
Alumina, Al_2O_3	16.36 "	17.28 "	13.81 "
Sesquioxide of iron, Fe_2O_3	4.39 "	4.88 "	5.08 "
Protoxide of iron, FeO	7.19 "	3.42 "	9.86 "
Lime, CaO	9.18 "	5.29 "	8.25 "
Magnesia, MgO	8.00 "	3.55 "	4.64 "
Soda, Na_2O	2.49 "	3.97 "	2.51 "
Potash, K_2O	1.17 "	3.54 "	1.12 "
Water, H_2O	2.39 "	.84 "	.27 "
	100.82	99.86	98.97

	Chem. series No. 186.		No. 187.	
Silica, SiO_2	61.19	per cent.	58.77	per cent.
Alumina, Al_2O_3	15.22	"	13.12	"
Sesquioxide of iron, Fe_2O_3	3.20	"	5.45	"
Protoxide of iron, FeO	3.55	"	6.87	"
Lime, CaO	7.94	"	5.99	"
Magnesia, MgO	2.38	"	4.93	"
Soda, Na_2O	3.17	"	1.94	"
Potash, K_2O	2.62	"	2.83	"
Water, H_2O	.40	"	.45	"
	99.67		100.35	

The nine analyses above reported are analyses of crystalline rocks. The analyses were made during the past winter by J. A. Dodge and C. F. Sidener.

	Chemical series No. 188.		No. 189.	
Silica, SiO_2	65.17	per cent.	20.90	per cent.
Magnetic oxide of iron, Fe_3O_4	30.06	"	70.29	"
Protoxide of iron, FeO	2.23	"	2.01	"
Dioxide of titanium, TiO_2	2.48	"	2.23	"
Lime, CaO	traces		traces	
Magnesia, MgO	traces		2.63	"
Alumina, Al_2O_3	traces		1.75	"
	99.94		99.81	
Total iron, Fe	23.50	"	52.46	"

	Chemical series No. 190.		No. 191.	
Metallic iron	54.1	per cent.	51.30	per cent.
Titanium	none		none	
Chromium	none		none	

The four analyses, 188, 189, 190, 191, are analyses of magnetic iron ores. They were made in April of this year by J. A. Dodge and C. F. Sidener.

	Chem. series No. 192.		No. 193.	
Silica, SiO_2	53.25	per cent.	42.10	per cent.
Alumina, Al_2O_3	21.13	"	15.12	"
Sesquioxide of iron, Fe_2O_3	6.88	"	5.14	"
Carbonate of lime, $CaCo_3$	2.42	"	17.80	"
Carbonate of magnesia, $MgCo_3$	3.78	"	5.53	"
Soda and potash	traces		traces	
Water, H_2O	11.59	"	14.00	"
	99.05		99.69	

The two analyses, 192 and 193, are analyses of clays, by C. F. Sidener.

Yours very respectfully,

JAMES A. DODGE, *Prof. Chemistry.*

VI.

RAILROAD ELEVATIONS.—BY. N. H. WINCHELL.

VI.

RAILROAD ELEVATIONS.

PREPARED BY N. H. WINCHELL.

ST. PAUL, MINNEAPOLIS & MANITOBA RAILWAY.

	Miles from St. Paul.	Feet above the Sea.
Junction of Osseo Branch	12.05	822.40
Parker	17.16	884
Shingle creek, bottom 868, water 871		882
Osseo	23.76	892
Elm creek, bottom 875, water 878		885
Rush creek, bottom 902, water 906		926
Maple Grove station		947
Hassan	34.03	977
Crow river, bottom 856, water 859	35.26	876
St. Michaels	38.17	963
Monticello	47.43	937
Silver Creek station	55.63	1117
Silver creek, 1¼ miles north of station, bottom 965, water 967		976
Clear Water river, bottom 935, water 942, high water of 1867, 957		964
Rice creek, bottom 954, water 956		966
Clear Water station	62.24	964
Plum creek, bottom 954, water 957		967
St Augusta creek, bottom 936, water 959		987
St Augusta station	69.23	1018
Three Mile creek (S. of St. Cloud), bottom 992, water 995		1016
St. Cloud depot	75.43	1041
Bridge over Mississippi river, water 976		1036.3
Sauk river, bottom 1035, water 1038		1053
St. Joseph	82.12	1092
Collegeville	84.91	1099
Avon	90.30	1135
Albany	96.35	1206
Getchell's creek, water 1197		1208
Freeport	102.62	1246
Sauk river, bottom 1174, water 1178		1190
Melrose	108.85	1247
Sauk river, bottom 1214, water 1228		1242
Sauk Centre	116.82	1260
West Union	124.65	1342

ST. PAUL, MINNEAPOLIS & MANITOBA RAILWAY.—*Continued.*

	Miles from St. Paul.	Feet above the Sea.
Osakis	130.50	1348
Nelson	136.16	1374
Alexandria	141.58	1396
Garfield	148.37	1422
Brandon	154.05	1393
Aldrich lake, bottom 1361	....	1374
Evansville	159.21	1294
Interlaken	166.07	1237
Pelican lake, water 1222	....	1234
Ashby	168.32	1300
Dalton	175.84	1366
Pomme de Terre river, water 1233	....	1268
Parkdale station	179.25	1283
Sand lake, water 1194	184.43	1195
Fergus Falls (depot)	186.51	1196
Carlisle	195.26	1239
Rothsay	203.85	1203
Lawndale	209.57	1088
Barnesville	218.43	1021
Downer	225.79	982.4
Glyndon	235.31	945.5
Averill	241.81	919.40
Felton	248.44	917.40
Borup	254.99	913.40
Ada	265.22	908.40
Lockhart	275.00	896.40
Rolette	276.72	895.40
Beltrami	282.06	904.40
Etna	....	905.40
Russia	287.99	895.00
Kittson	292.35	888.40
Carman	298.00	885.40
Crookston (river 842)	299.32	868.40
Shirley	305.82	905.40
Euclid	313.23	895
Angus	321.12	875
Warren	329.80	858
Argyle	339.60	850.40
Stephen, bottom of Tamarack river, 816	348.11	832.40
Donaldson	356.59	831.40
Kennedy	361.46	830.40
Hallock	370.50	820
Northcote	376.18	807.40
Humboldt	383.00	797
St. Vincent	390.25	792.50
International boundary	391.07	795

Brown's Valley Branch.

	Miles from St. Paul.	Feet above the Sea.
Graceville	....	1106.8

ST. PAUL, MINNEAPOLIS & MANITOBA RAILWAY.—*Continued.*

St. Cloud & Hinckley Branch.

	Miles from St. Paul.	Feet above the Sea.
Oak Park	....	1118.64
Foley	....	1122
Downer	....	968.4

From Fergus Falls to Pelican Rapids.

	Miles from St. Paul.	Feet above the Sea.
*Junction	....	1174
Elizabeth	198.96	1256
Ehrhardt	202.42	1301
Pelican river, 2 miles S. from Pelican Rapids. [Bottom 1297]	....	1304
Pelican Rapids	208.40	1319

From Shirley to St. Hilaire.

	Miles from St. Paul.	Feet above the Sea.
Shirley	305.82	905.40
Ives, gravel ridge, top of ridge 1002	314.43	998.70
St. Hilaire	327.28	1090.70
Black river, 3.4 miles N. E. of Ives, water 981	....	1002
Gravel ridge, ½ mile E. of Black river	....	1007

WISCONSIN CENTRAL RAILROAD.

By F. W. Fratt.

	Miles from St. Croix.	Natural Surface.	Grade Elevations.
St. Croix river, bottom 705, low water 715, high water	.0	728	794
Highway	1.2	858	860

* This branch starts from the Northern Pacific Railway, half a mile east of the Manitoba freight yard, and runs level northeasterly till it crosses the Red river.

WISCONSIN CENTRAL RAILROAD.—*Continued.*

	Miles from St. Croix.	Natural Surface.	Grade Elevation.
Arcola	2.4	920	917
Government road	3	898	901
Carnelian lake, water	4.6	912	920
Highway, Sec. 6, 30-20 W	7.25	991	992
Highway, Sec. 12, 30-21 W	9.25	951	955
Crossing St. P. & D. R. R	11	1035	1017
Summit, Sec. 28, 30-21 W	13.3	1085	1074
Four Lakes station	14.6	1015	1005
Long lake, water	15.2	975	990
Castle	16.9	1024	1025
Junction St. P. & D. R. R	20.4	....	938

NORTHERN PACIFIC RAILROAD.

	Miles from St. Paul.	Feet above the Sea.
St. Paul	0	701
Minneapolis	11	832
Fridley	18	848
Coon Creek	25	860
Anoka	29	883
Itaska	36	891
Elk River	41	901
Bailey's	45	918
Big Lake	50	940
Becker	57	976
Clear Lake	64	997
Haven	71	1011
E. St. Cloud	76	1030
Sauk Rapids	77	1004
Watab	83	1053
Rice's	90	1059
Royalton	97	1080
Gregory	103	1095
Little Falls	107	1115
Belle Prairie	112	1130
Topeka	116	1144
Fort Ripley	121	1158
Albion	126	1173
Crow Wing	130	1186
Brainerd	138	1208
Mississippi river, low water	....	1152
Gull river	146	1189
Sylvan Lake	148	1203
Pillager	151	1200
Bath	156	1212
Motley	160	1223
Staples Mills	168	1250
Dower Lake	170	1290

NORTHERN PACIFIC RAILROAD.—*Continued.*

	Miles from St. Paul.	Feet above the Sea.
Aldrich	174	1327
Verndale	178	1347
Wadena	185	1349
Wadena Junction	187	1350
Bluffton	190	1310
Amboy	193	1376
New York Mills	197	1409
Richmond	203	1394
Perham	209	1367
Luce	214	1370
Frazee	220	1384
Johnson	225	1393
Detroit	230	1362
Audubon	237	1308
Lake Park	242	1334
Hillsdale	248	1399
Hawley	254	1150
Muskoda	258	1090
Glyndon	267	924
Tenny	269	920
Moorhead	275	903
Red river, low water	....	867

Little Falls & Dakota Division.

	Miles from Little Falls.	Feet above the Sea.
Little Falls	0	1115
Mississippi river	....	1081
La Fond	7	1184
Swan river, low water	....	1152
Swanville	11	1171
Manley Creek	....	1171
Gray Eagle	26	1223
Summit, 2½ miles east of Gray Eagle	....	1223
Birch Lake station	29	1227
Spaulding	31	1292
Summit, 1½ miles W. of Spaulding	....	1338
Sauk river, low water	....	1219
Sauk Centre	37	1242
St. P., M. & M. grade	....	1253.5
Westport	48	1332
Villard	53	1358
Summit, 1 mile E. of Glenwood	....	1413
Glenwood	60	1402
Trappers' run, near Pelican lake	....	1144
Minnewaska lake	....	1135

Little Falls & Dakota Division.—Continued.

	Miles from Little Falls.	Feet above the Sea.
Starbuck	69	1160
Little Chippewa river, low water		1160
Summit, 2 miles W. of Little Chippewa		1193
Big Chippewa river, low water		1120
Cyrus	79	1150
Summit, 2½ miles W. of Cyrus		1200
Pomme de Terre river		1087
Morris depot		1129

Fergus Falls & Black Hills Division.

	Miles from Wadena.	Feet above the Sea.
Wadena	0	1349
Wadena Junction	1	1350
Deer Creek	10	1394
Parkton	14	1394
Henning	18	1437
Vining	24	1389
Clitheral	29	1346
Battle Lake	33	1354
Maplewood	39	1360
Underwood	42	1343
Red river, first crossing 1231, second crossing		1174
Fergus Falls, low water of river 1150	53	1183
Pelican river, low water		1124
French	59	1085
Ames	60	1063
Everdell	69	992
Breckenridge	77	960
Bois des Sioux, low water		946
Wahpeton	78	963

Wisconsin Division.

	Miles from L. Superior.	Feet above the Sea.
Chequamegon bay, lake Superior	0	602
Ashland	2	669
Omaha Junction	6	642
Moquah		849
Iron		1036
Iron river		1094

Wisconsin Division — Continued.

	Miles from L. Superior.	Feet above the Sea.
Muskeg	....	1100
Topside	....	1151
Brule	....	990
Blackberry	....	1134
Maple Ridge	....	1093
Midland	....	939
Cutter	....	732
Superior	64	608
Bay of Superior, water	....	602
Walbridge	76	842
Carlton	79	938
N. P. Junction	87.5	1080

Duluth and Brainerd Line.

	Miles from Duluth.	Feet above the Sea.
Lake Superior	....	602
Duluth	0	608
N. P. Junction	23	1080
Pine Grove	28	1235
Norman	33	1315
Corona	39	1301
Cromwell	45	1304
Wright	51	1307
Tamarack	57	1269
McGregor	66	1226
Kimberly	75	1235
Aitken	87	1207
Cedar Lake	92	1220
Deerwood	97	1275
Jonesville	108	1236
Brainerd	114	1208

ST. PAUL & NORTHERN PACIFIC RAILROAD.

	Miles from St. Paul.	Feet above the Sea.
Small iron bridge, near Fourth street, St. Paul	....	716.86
East Seventh street	....	726.64
Trout brook, water 737.64	1	747.64
Westminster street	....	752.64
Crossing Manitoba R. R	....	757.64
Crossing St. P., M. & O. Ry	....	762.14

St. Paul & Northern Pacific Railroad — Continued.

	Miles from St. Paul.	Feet above the Sea.
Trout brook, crossing second time, water 765.64	1.4	768.64
Mississippi street	1.6	773.64
Trout brook, water 790.64, public road, 792.64	2.1	798.64
Cortland street (cut 30 feet)	2.4	817.64
Rice street	....	835.64
Crossing of creek	3.5	856.64
Western avenue	3.6	858.64
Dale street	4.3	889.64
Como avenue	4.6	910.64
Como road	4.7	912.14
Section line between 27 and 26	5.2	925.64
Summit on the Como property	5.6	977.84
Snelling avenue (section line 28 and 27)	6.2	920.64
Cut of 20 feet	6.4	912.64
Track to Fair grounds	6.5	909.64
Westwood avenue (fill 13 feet)	6.8	899.64
Section line between 29 and 28, on Rich avenue	7.3	898.64
Raymond avenue	7.6	902.64
Bayless avenue	7.7	903.64
Transfer track St. P., M. & M	7.9	902.24
County line crossing (in St. Anthony Park)	8.4	885.64
Mary street (edge of bluffs)	8.6	856.64
Chicago, Milwaukee & St. Paul Railway crossing	9.2	827.64
University avenue, Minneapolis	9.4	827.64
Cut along Arlington street descends from 827.64 to	....	815.64
Church street	....	822.64
State street	....	818.64
Pleasant street	9.6	816.14
The ground on which the University stands at the place of this cut	....	848
Level of bridge	....	815.64
Top of the limestone ledge at the bridge, east side 789.64 west side*	....	784.64
Top of sand rock, east side 759.64, west side	....	759.64
Bottom of Mississippi river	10	716.64
Low water in rapids	....	720.64
Nineteenth avenue S	....	812.64
Bluff street	....	811.64
Cedar avenue	10.4	810.64
Tenth avenue S., natural surface	....	815.64
Depot, St. P., M. & M. Ry	11.4	813.14
Hennepin avenue at St. P., M. & M	11.4	831.64
Grade at First avenue N	....	817.64
Street at First avenue N	....	836.64
First street N. (street level 841.64), grade	....	824.64
Fourth avenue N. (street at 4th. avenue N. 846.64), grade	11.9	825.64

* The apparent difference of level of the limerock on the east and west sides of the river is probably due to a difference in the amount of erosion and not to a dip in the formation.

Line B (Through Elwelltown).

	Miles from St. Paul.	Feet above the Sea.
Bayless avenue in St. Anthony Park		903.64
Last cut in the bluffs (24 feet)		890.64
Como avenue	9.3	858.64
Division street	9.7	856.64
St. Paul & Duluth Ry.		850.64
Fillmore street	10.7	849.64
Harrison street		848.64
Monroe street	11.3	841.64
Twenty-third avenue N. E.	11.6	849.64
Twenty-fourth avenue N. E.	11.8	850.64
Bridge over Mississippi river (Twenty-fourth ave.)	13.2	825.64
High water, 803.64; low water		794.64

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

Line between Minneapolis and Cologne.

	Miles from Minneapolis	Feet above the Sea.
Depot, Minneapolis	0	825
Short Line Junction	1.8	843.66
Cedar avenue (grade of street, 866.66.)	2.3	859.66
Chicago avenue	3	864.66
Portland avenue	3.3	866.16
Nicollet avenue	3.8	876.36
Lyndale avenue	4.3	878.66
Hennepin avenue	4.8	879.66
Long station	5.3	860.91
Cut of 18 feet	5.8	876.66
Bass lake (water 879.66)	6.9	885.66
Summit	8	918.66
Marsh (marsh level 890.66)	8.4	900.66
Hopkins station (C., M. &. St. P.)	8.8	912.66
Crossing, spur track of M. & St. L.	8.9	911.66
Minnehaha creek	9	911.66
Hopkins station (M. & St. L.)	10.1	922.66
Davis creek	11.1	900.66
Shady Oak lake (water 906.66)	12	910.66
Foot of Mud lake (water 904.66)	12.6	909.66
Crossing M. & St. L. Ry	13	922.66
Island lake (water 893.66)	14.5	898.66
Purgatory creek (bottom 839.66)	15.3	901.66
Duck lake (water 911.66)	15.7	921.66
Chanhassen	18.2	967.16
Marsh	20.1	914.36
Lake Hazeltine (water 918.66)	21.6	923.66
Hazeltine	21.8	929.66
Chaska creek (water 896.66)	22.5	938.66
Summit	23.5	962.66

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—*Continued.*

	Miles from Minneapolis.	Feet above the Sea.
Fill (natural surface 922.66)	25.2	934.66
Augusta	27	979.66
Lake avenue	28.4	946.66
Carver creek (water 912.66)	29.8	922.66
Cologne	30.5	943.66

Elevations on the Stillwater Branch.

	Miles from Stillwater.	Feet above the Sea.
Stillwater (on trestle work)	....	696.64
Stillwater, extreme high water of lake	....	695.14
Stillwater, water July 10, 1881	....	684.14
Baytown (or S. Stillwater)	3.3	696.64
Lakeland	8.2	744.64
Afton	11.1	697.14
Trout brook (water, lake level)	14.4	701.64
Straight Cooley	16.9	702.64
Point Douglas	22.7	711.64
Junction with River Division	25.6	696.64

Short Line from St. Paul to Minneapolis.

	Miles from St. Paul.	Feet above the Sea.
Chestnut street, St. Paul	.8	710.41
Fort street	....	789
Grace street	2.8	829.66
St. Clair street	3.5	876.66
Big cut, natural surface 929.66, centre	3.8	901.66
Under Summit avenue	4	908.66
Summit (Snelling avenue)	4.8	938.66
Merriam Park	5.8	909.66
Ford's Nursery	6.6	874.66
Hennepin county line	7	849.66
Top of rock bluff, east bank	7.3	800.66
Mississippi river, high water 725.86, low water	....	710.66
Bridge over the river	7.3	844.66
Minnehaha avenue	8.8	843.66
Short Line Junction	9	843.66
Depot (Washington avenue)	10.8	825

CHICAGO, BURLINGTON & NORTHERN RAILROAD.

	Miles from St. Paul.	Feet above the Sea.
Pig's Eye bridge	2	707.5
Newport	7.5	749.8
Quarry	14.8	699
Altenberg Cooley	17	695.5
Hastings, bluff crossing (Pt. Douglas)	19	693.5
Point Douglas, highway crossing	21	710
St. Croix river, bottom 652	21.8	702.4

ST. PAUL & DULUTH RAILROAD.

Branch from Wyoming to Taylor's Falls.

	Miles from St. Paul.	Feet above the Sea.
Wyoming	29.8	896
Junction near Wyoming, about 1-6 of a mile south from the depot	29.65	898
Summit, natural surface 909, grade	30.4	903
Summit, natural surface and grade	33.6	922
Chisago City	36.0	917
Trestle bridge over Chisago lake, water 896, grade	38.4	928
Lindstrom	38.6	932
Summit, natural surface and grade	39.1	937
Chisago lake, water 896, grade	40.2	901
Centre City	40.3	901
Bridge at Centre City, bottom 861.5, grade	....	901.5
Summit, natural surface 950, grade	42.6	946
Siding	43.8	937
Franconia	45.8	915
Lawrence creek, bottom 857, water 861, grade	46.3	901
First sandrock cut	47.8	855
Trap-rock cut, top of rock 823, grade	48.9	797
Taylor's Falls, passenger depot	49.1	791
Taylor's Falls, freight depot and yard	49.9	750

Branch from Rush City to Grantsburgh, Wis.

	Miles from St. Paul.	Feet above the Sea.
Junction near Rush City, about 1-5 of a mile south from the depot	53.6	916
Rush creek, water 841, grade	56.3	849
St. Croix river, water 775, grade	58.6	795
Summit, natural surface and grade	69.1	921
Grantsburgh	70.2	895

Knife Falls Branch.

	Miles from St. Paul.	Feet above the Sea.
Northern Pacific Junction	....	1082
Knife Falls station	....	1179
Knife Falls, high water (St. Louis river)	....	1171.55
Knife Falls, low water (St. Louis river)	....	1166.55

From White Bear to Stillwater.

	Stations.	Feet above the Sea.
Junction near White Bear lake	0	938
White Bear lake, water 926	72	935
Dellwood	104	942
Mahtomedi, low point in grade	155	927
Summit of grade, cut 20 feet	340	984
Summit	410	919
Brown's creek, bottom 858	502	867
Brown's creek, bottom 837	530	853.5
Depot at Stillwater	617	723
Grade at the lake (Myrtle street)	650	686
St. Croix lake, at Stillwater	650	672.5

CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RAILWAY.

Ed. Johnson, Chief Engineer.

Blue Earth Branch.

		Feet above the Sea.
Lake Crystal	....	1003.16
Garden City	....	966
Vernon Centre	....	1028
Amboy	....	1048
Winnebago City	....	1101
Crossing of the C., M. & St. P. Ry. at Winnebago	....	1109
Blue Earth City	....	1088
Elmore	....	1131

CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RAILWAY.— *Continued.*

Eastern Division.

		Feet above the Sea.
St. Paul, east end of Union Depot sheds	....	708
Mississippi river	....	688
St. Paul Junction with St. P., M. & M. (near East St. Paul)	....	780
East St. Paul	....	827
Midvale	....	1012
Oakdale	....	984
Lake Elmo	....	938
Stillwater Junction	....	884
Lakeland Junction	....	811
River Falls Junction	....	702
St. Croix lake at Hudson	....	679
Hudson	....	723

Superior Junction to Duluth.

		Feet above the Sea.
Superior Junction	....	1091.50
Nunekagon river, water	....	1039
Lake Side	....	1110
Gordon (St. Croix river, 1017)	....	1033
White Birch	....	1135
Three miles N. of White Birch	....	1240
Hawthorne	....	1156
Douglas	....	963
Superior Short Line Junction	....	647
Superior Junction with N. P.	....	637
Superior, depot	....	645
West Superior	....	624
Rice's Point, Duluth	....	619.50
St. Louis bay, water	....	603.50

Western Division.

		Feet above the Sea.
St. Paul	....	708
Mississippi river, low water	....	688
Mendota, depot (C., M. & St. P. Ry.) 727	....	722
Nicols	....	722

CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RAILWAY.—*Continued.*

Western Division.—Continued.

		Feet above the Sea.
Hamilton		723
Barden		747
Shakopee depot		751
Shakopee, crossing (H. & D. Ry.) at grade		758.50
Merriam Junction, crossing (Minn. & St. L.) at grade		745
Jordan		758
St. Lawrence		754
Belle Plaine		733
Blakeley		737
E. Henderson		731
Le Sueur		751
Ottawa		799
St. Peter		757

Sioux Falls Branch.

		Feet above the Sea.
Sioux Falls Junction		1643
Rushmore		1675
Adrian		1558
Drake		1636
Warner		1482
Luverne, crossing at grade, B., C. R. & N		1457
Luverne, depot		1471
Luverne, junction with Rock River Branch		1471
Beaver creek		1463
Valley Springs		1411
Brandon		1336
Sioux Falls, crossing at grade C., M. & St. P., 1418		1414
Hartford		1580
Montrose		1480
Salem, depot		1537

Rock River Branch.

		Feet above the Sea.
Luverne		1471
Ash creek		1415
Rock Rapids		1464
Doon		1305

CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RAILWAY.—*Continued.*

Black Hills Branch.

		Feet above the Sea.
Heron Lake station	....	1425
Dundee	....	1453
Lime creek	....	1488.50
Avoca	....	1542
Slayton	....	1614.50
Hadley	....	1698.50
Lake Wilson	....	1665.50
Woodstock	....	1831.50
Pipestone, crossing at grade B., C. R. & N	....	1734.50
Pipestone depot	....	1729.50

MINNEAPOLIS & ST. LOUIS RAILWAY.

Pacific Division.

From the profiles by G. Iffinger.

	Miles from Minneapolis	Feet above the Sea.
Hopkins	8.7	921
Minnetonka Mills	11.7	936
Tamarack marsh, bottom 880	14.5	909
Hotel St. Louis	15.8	943
Carson's bay, water 928, 18 feet deep	16	933
Solberg point, on bridge	17.9	938
Excelsior	18.9	947
Centennial House	25	936
Waconia	31.5	986
Marsh, surface 978	34-34.7	981
Young America	39.1	993
H. D. crossing	40.3	976
Hamburg	43.8	1000
Carver and Sibley county line	45	995
Green Isle	48.1	1001
Arlington	54.3	995
Branch of Rush river, outlet of Felton lake, water 981.5	58.3	996
Gaylord	62.3	993
Winthrop	69.3	1015.5
Rush river, bottom 1022.5	71.8	1030
Gibbon	77.4	1046
Sibley and Renville county line	82.2	1046
Mud creek, bottom 1022	84.2	1038
Fairfax	86.9	1041.5

MINNEAPOLIS & ST. LOUIS RAILWAY.—*Continued.*

Pacific Division.—Continued.

	Miles from Minneapolis	Feet above the Sea.
Three Mile creek, bottom 1015	90.2	1024
Franklin	94.9	1005.2
Purgatory creek, bottom 966.5	95.4	997
Johnson's creek, bottom 941	95.8	983
Thompson's creek, bottom 871	96.5	938
Campbell's creek, bottom 868	97	913
Birch Cooley creek, bottom 827.5	98.7	837
Morton	100.4	841
Minnesota river, bottom 814	100.9	840
Bottomland of Minnesota river	101.4	827

CHICAGO & NORTHWESTERN RAILWAY.

E. Johnson, Chief Engineer.

		Feet above the Sea.
*Sleepy Eye station		1027
Junction one mile west		1008
Morgan		1043
Paxton		1032
Redwood Falls station		1026
The river, west of the station		946
This river elevation is above the rapids at the head of the falls.		

* Lake Michigan is given by the U. S. Lake Survey at 582, which makes Sleepy Eye 1027. Gannett gives for Sleepy Eye station (C. & N. W. Ry.) 1020, and for Sleepy Eye 1034. The latter Mr. Upham has used in final report, p. 565.

The figures given above by Mr. Johnson differ by 7 feet from the one and 5 feet from the other.

MINNEAPOLIS, LYNDALE & MINNETONKA RAILWAY.

From the profiles in the office of Geo. W. Cooley.

	Miles from Bridge Sqr.	Feet above the Sea.
First street, Bridge square	.00	837.5
Second street		838
Crossing of Washington avenue		842

MINNEAPOLIS, LYNDALE & MINNETONKA RAILWAY.— *Continued.*

	Miles from Bridge Sqr.	Feet above the Sea.
Crossing of Third street		840
Crossing of Fourth street		847
Crossing of Fifth street		850
Crossing of Sixth street		854.5
Crossing of Seventh street		852
Crossing of Eighth street		852
Crossing of Ninth street	.54	844.5
Crossing of Tenth street		850
Crossing of Eleventh street		850.5
Crossing of Twelfth street		854
Crossing of Thirteenth street and First avenue S	.86	852
Crossing of Thirteenth street and Nicollet avenue		847
Crossing of Grant street	1.02	841
Crossing of Fourteenth street		844
Crossing of Fifteenth street		849
Crossing of Sixteenth street		852
Crossing of Seventeenth street		854.5
Crossing of Eighteenth street		863.5
Crossing of Nineteenth street		867
Crossing of Franklin avenue (or Twentieth street)	1.52	878.5
Crossing of Twenty-second street		897
Crossing of Twenty-fourth street		895
Crossing of Twenty-fifth street		888
Crossing of Twenty-sixth street		874
Crossing of Twenty-seventh street		871
Crossing of Twenty-eighth street	2.26	872
Crossing of Twenty-ninth street		873
Crossing of H. & D. Ry		872.5
Crossing of Twenty-ninth and one-half street		872
Crossing of Lake street		871
Crossing of Thirty-first street		869
Crossing of Blaisdell avenue		870
Crossing of Lindley avenue		871
Crossing of Pleasant avenue		876
Crossing of Grand avenue		876
Crossing of Harriet avenue		877
Crossing of Rogler avenue		878
Crossing of Lyndale avenue	3.11	877
Crossing of Aldrich avenue		876.5
Crossing of Bryant avenue		876
Crossing of Colfax avenue		877
Crossing of Dupont avenue		878
Crossing of Emerson avenue		879
Crossing of Fremont avenue		880.5
Crossing of Girard avenue		881.5
Crossing of Hennepin avenue	3.61	883
Crossing of Humboldt avenue		881
Crossing of Irving avenue		882
Crossing of Knox avenue		883
Crossing of Thirty-second street		885
Crossing of Thirty-third street		883.5
Depot at Lake Calhoun	4.14	883.5
Depot at Lake Harriet		862
Crossing of the centre line of sec. 8		891
Crossing of the centre line of sec. 7	6.80	903

MINNEAPOLIS, LYNDALE & MINNETONKA RAILWAY.—*Continued.*

	Miles from Bridge Sqr.	Feet above the Sea.
Crossing of Minnehaha creek, water 886; bottom 860	7.44	871
Marsh, water, 867, bottom 853	7.54	871
Crossing of centre line, Sec. 19 (Mendelssohn), natural surface 933	9.44	920
Crossing of H. & D. Ry	10.14	898
Crossing of M. & St. L. Ry	10.54	901
Marsh, N. W. ¼ Sec. 25, water 885	10.74	889
Divide, N. E. ¼ Sec. 27	12.14	953
Depression, S. W. ¼ Sec. 27, near Glen lake	13.14	906
Marsh, near centre of Sec. 33, water 918	13.64	924
Divide	14.64	945
Purgatory creek, S. W. ¼ Sec. 29, water 860.5, bottom 858	15.44	897
Divide, natural surface 994	17.44	975
Marsh, part of Christmas lake, surface 915	18.44	990
Crossing of M. & St. L. at Excelsior	18.50	921.8
Junction of Hutchinson extension with the old motor line.	18.79	922
Excelsior depot	18.97	928
Excelsior depot of M. & St. L. Ry., same level as this road	19.54	931
Crossing of line, Secs. 32 and 33	21.79	965
Crossing Carver county line	22	968
Depression, near Lake Minnewashta	24	933
Crossing M. & St. Louis Ry., end of Schutz lake	24.09	959.5
Centennial lake, water 930	25.01	934.24
Summit, N. E. corner Sec. 4	27.22	977
Outlet of Parley lake, north side Sec. 5, water 910	28.79	928
Summit	30.09	959
Clearwater lake, Coney Is. Sta., water 946	31.05	953
S. W. ¼ Sec. 2	32.15	957
Crossing of line, Secs. 3 and 4	35.81	961
Crossing of Crane creek, centre of Sec. 2, bottom 913	37.85	938
Crossing of line, Sec. 4 and 5, T. 116, R. 116	40.19	971
Crossing Crane creek, W. ½ Sec. 6, water 934	42.24	943
Otter creek, E. ½ Sec. 1, bottom 938	42.85	947
Lester Prairie station	43.95	960
E. ½ Sec. 4, T. 116, R. 27 (Luth. church)	45.60	1007
Outlet of Mud lake	50.26	1024
Summit, E. ½ Sec. 4, T. 116, R. 28	51.47	1040
Crossing Bear creek, E. ½ Sec. 6, T. 116, R. 28, bottom 1009	53.36	1028
Summit, W. ½ Sec. 2, T. 116, R. 29	56.15	1053
Summit, W. ½ Sec. 4, natural surface 1062, highest point on the line	58.15	1053
Crossing Crow river, bottom 1006	59.75	1027
Hutchinson station, corner Washington and Adams streets	60.05	1023

DULUTH & IRON RANGE RAILROAD.

Natural Surface Levels.

	Miles from Duluth.	Feet above the Sea.	Grade Levels.
Water level Lake Superior		602	....
Connection with St. Paul & Duluth R. R	.00	608	608

DULUTH & IRON RANGE RAILROAD.— *Continued.*

Natural Surface Levels.— Continued.

	Miles from Duluth.	Feet above the Sea.	Grade Levels.
Summit	.55	656	635
Chester creek, bottom	.81	602	632
Summit	1	627	632
Depression	1.33	612	633
Rock-cut, summit	1.90	664	657
Summit	2	658	670
Tischer creek, bottom	2.58	634	667
Summit	3	690	686
Summit, station "New London"	4	690	685
Summit, station "Lester Park"	5	655	650
Lester river, bottom	5.34	604	650
Summit	6.25	668	660
Summit	7.50	667	665
Summit, station "Clifton"	8	656	661
Summit	9.25	676	673
Talmage river, bottom	10.69	658	691
Summit	11	699	700
Summit	12	704	697
French river, bottom	12.10	677	697
Summit	12.20	710	697
Smith's creek, bottom	12.65	650	696
Summit	13	709	700
Summit	14.50	699	697
Big Sucker river, bottom	14.83	630	684
Summit	15	689	687
Little Sucker river, bottom	15.63	612	664
Summit, station "Lake View"	16	663	661
Stony Point	16.71	680	671
Rock	17	667	662
Rock	17.50	678	666
Summit	18	646	645
Knife river, bottom, station "Knife River"	18.70	602	620
Summit	19.25	644	641
Summit	20	666	657
Summit	21	653	651
Rock	21.65	683	675
Summit	22	701	693
Rock	22.21	707	697
Summit	23	723	716
Summit	23.50	734	732
Summit	24.50	768	767
Depression	25.51	677	696
Summit	25.75	686	687
Two Harbors, a junction	26.10	692	692
Two Harbors, depot, 2520ft. from junction	....	632	634
Summit	26.53	688	690
Summit	27.46	874	873
Summit	27.93	902	897
Summit	28.27	928	932
Summit	28.92	1032	1017
Summit	29.58	1060	1060

DULUTH & IRON RANGE RAILROAD. —*Continued.*

Natural Surface Levels.—Continued.

	Miles from Duluth.	Feet above the Sea.	Grade Levels.
Summit	30.36	.1097	1099
Summit	31.45	1221	1213
Summit, station "Sibiwissa"	32	1236	1230
Summit	32.61	1302	1294
Summit	33.66	1395	1375
Summit	34.40	1440	1433
Summit	35.53	1522	1511
Summit	36.24	1597	1584
Summit	36.88	1659	1652
Summit	37.18	1722	1706
Summit, highest point, station "Gakadina"	38.84	1760	1734
Summit	39.20	1720	1712
Summit	40.23	1644	1642
Summit	40.46	1683	1653
Depression	41.33	1594	1602
Summit	41.67	1630	1616
Summit	42.36	1610	1608
Summit	43	1562	1564
Summit	43.80	1570	1545
Little Cloquet river, bottom	44.20	1498	1521
Summit	44.50	1534	1526
Summit	45.43	1492	1490
Cloquet river, bottom. station "Cloquet River"	46.22	1477	1490
Summit	47.55	1554	1545
Summit	48.67	1586	1570
Summit, Wissakode	49.46	1582	1578
Summit	50.38	1607	1596
Summit	51.44	1619	1617
Summit	52.67	1644	1615
Outlet Bassett lake, bottom	53.18	1570	1587
Summit	53.91	1640	1630
Summit Bassett lake	54.97	1661	1642
Whiteface river, bottom	55.41	1609	1635
Summit	55.84	1676	1655
Summit	56.84	1637	1638
Summit	57.22	1682	1672
Summit	57.75	1707	1693
Summit	58.55	1657	1657
Summit	59.86	1652	1648
Summit	60.68	1619	1614
Summit	61.53	1609	1607
St. Louis river, bottom, station St. Louis River	62.07	1594	1607
Summit	63.56	1609	1607
Summit	64.91	1574	1569
Summit	65.50	1546	1543
Summit	67	1524	1516
Partridge river, bottom	68.26	1499	1514
Summit	69.24	1504	1510
Beaver Dam creek, bottom, Okewanim	70.20	1481	1494
Summit	71.37	1519	1514
Summit	72.18	1543	1536
Summit	73.20	1514	1514

DULUTH & IRON RANGE RAILROAD.—*Continued.*

Natural Surface Levels.— Continued.

	Miles from Duluth.	Feet above the Sea.	GradeLevel.
Mesaba creek, bottom	73.68	1479	1486
Summit	74.78	1564	1559
Mesaba Heights, station	75.32	1611	1604
Summit	76.30	1541	1538
Summit	77.41	1489	1487
Summit	78.62	1445	1440
Depression Embarrass river bottom	80.38	1421	1440
Summit	81.54	1454	1448
Summit	82.46	1484	1477
Summit	83.50	1489	1479
Summit	84.92	1507	1484
Summit	85.74	1452	1448
Summit	86.94	1479	1470
Summit	88.91	1453	1446
West Two Rivers, bottom	89.39	1414	1424
Summit	89.52	1442	1418
West Two Rivers, bottom	89.72	1401	1413
Summit	90.38	1449	1439
Summit	91.20	1414	1406
East Two Rivers, bottom	91.79	1374	1384
Summit	92.45	1389	1381
Summit	92.76	1407	1402
Summit	93	1419	1415
Breitung Mine station, Tower yard	93.97	1434	1424
Tower	95.75	....	....
Vermilion lake, water level	....	1357	....

DULUTH & MANITOBA RAILROAD.

[*Operated by the Northern Pacific Railroad Company.*]

From profiles in the office of J. B. Holmes, President, Minneapolis.

	Miles from Winnipeg Junction.	Feet above the Sea.
Winnipeg Junction, 227 miles from Duluth	.0	1181
Buffalo river, bed 1150, grade	0.5	1172
Summit, natural surface and grade	5.8	1253
Ulen	13	1154
South branch of Wild Rice river, bed 1113, grade	13.6	1135
Twin Valley	25.5	1093
Wild Rice river, bed about 985, grade	27.6	1010
Norman	33.8	1099
Sand Hill river, bed 1075, water, July, 1886, 1085; grade	44.5	1115

DULUTH & MANITOBA RAILROAD.—*Continued.*

	Miles from Winnipeg Junction.	Feet above the Sea.
Fertile	45.5	1140
Kittleson creek, bed 1094, grade	48.1	1124
Crossing Fosston branch of St. Paul, Minneapolis & Manitoba railway	57.1	1116
Tilden	57.3	1116
Badger creek, bed 1033, grade	64.9	1045
Junction of Red Lake Falls spur	68.7	1038
Red Lake Falls (on this spur)	69.3	1037
Red Lake river, bed 934, grade	70.6	966
Summit, cutting 9 feet, grade	73	1013
Black river, bed 941, grade	75.9	976
Crossing Saint Hilaire branch of St. P., M. & M. Ry	78.3	979
Crossing St. Vincent line of St. P., M. & M. Ry	86	903
Water-tank, grade	90	874
Junction of Keystone spur	93.3	857
Keystone (at end of this spur)	96.3	857
Grand Marais slough (former channel of Red Lake river), bed 813, grade	101.6	830
East Grand Forks	104.7	833
End of spur to river, East Grand Forks	105.1	809
Red river, bed 779, low and high water, 784-821	....	....

[This road was built in 1886. Above notes copied from profiles by Warren Upham, May 16,1887.]

VII.

MINNESOTA GEOGRAPHICAL NAMES DERIVED FROM THE CHIPPEWA LANGUAGE.

VII.

MINNESOTA GEOGRAPHICAL NAMES DERIVED FROM THE CHIPPEWA LANGUAGE.

BY REV. J. A. GILFILLAN.

[NOTE.—In order to present as nearly as possible a complete account of the aboriginal geography of Minnesota, Mr. Gilfillan was requested to prepare the following list for this use, thus supplementing the list of Mr. Williamson of Dakota names published in the thirteenth annual report. Mr. Gilfillan deposited the original manuscript with the Minnesota Historical Society, at St. Paul; and it was by vote of the executive council, at the request of Mr. Gilfillan, that the manuscript was copied and is published herewith. N. H. W.]

WHITE EARTH RESERVATION, MINN., April 13, 1885.

The Minnesota Historical Society,

GENTLEMEN: I have the honor to inclose to your honorable society a list of some 430 odd names of rivers, lakes, etc., in Minnesota, and some in the adjoining territories of Dakota, Manitoba, and state of Wisconsin, in the Ojibway or Chippeway language. This represents the labor of some weeks, and some money paid to those whom I employed, both which I gladly give to science and those who shall come after us. They will be interested in knowing what the first inhabitants named the places where they will have reared their happy homes and often an interest beyond that of mere curiosity will attach to those names. The Ojibway Indian is a very close observer, a name either of a person, or a place with him always *means something*, and is never a mere arbitrary designation as with us, but expresses the *real essence of the thing*, or its dominating idea as it appears to him.

Abundant proof of this remark will be found in the following pages where the peculiar and striking physical characteristics of

a lake or river will often be found condensed in a single word of its name. Names cling very tenaciously and survive the total sweeping away of the ancient inhabitants who named them; as is abundantly evidenced in our own country and in those beyond the sea, where the names of localities given by the original Irish race, for instance, remain, though another race totally different in blood, religion and language has come in and occupied their place.

In compiling the accompanying list of names, I have, besides the knowledge of them obtained by myself while journeying more or less for nearly 13 years past in nearly all parts of the Ojibways in Minnesota, called to my aid Indians and mixed bloods familiar with the different localities by having journeyed or lived there.

Thus from some I have obtained the rivers, etc., in Dakota bordering on Minnesota; from others those in the British Possessions; from others those connected with Otter Tail lake and river, etc., etc.

I have taken pains to be accurate, and to put down nothing doubtful; and if in any instance I have erred it has not been willfully.

In treating of the two principal rivers of Minnesota, the Mississippi and Red rivers, I have followed the plan of beginning at the source and tracing them along.

Many of the names are in localities yet unsettled by white men, but they will be settled one day, and in the near future, and then those names will be of interest. The English names I have taken from Warner and Foote's map of Minnesota published in 1881, as being the best to which I had access.

The list is not yet complete. There are many lakes between Red and Cass lakes, for instance, which I have not yet had opportunity to get, but names of which I hope to get when I go there, and send to the society. Since making the list I have learned of one slight correction; that the Indians call a part of the Mississippi above Cass lake by a different name, which name I hope to get and send the next time I visit Cass lake and talk with the Indians there.

It is hardly necessary to say that knowing the Indian language has alone enabled me to make this slight contribution.

Believe me, very respectfully yours,

J. A. GILFILLAN,

Missionary to the Ojibway Indians.

KEY TO THE ORTHOGRAPHY.

A, a,	is pronounced as	a in *what*.
E, e,	"	" e in *men*.
I, i,	"	" i in *pin* or *machine*.
O, o,	"	" o in *note*.
U, u,	"	" u in *full*.

The *consonants* are sounded as in English.

Diphthongs.

Ai	is pronounced as	the pronoun *I*.
Au	"	" ow in *now*, *vow*.
Ia or ia	is pronounced as	ya (a in *father*).
Ie or ie	"	" ye (a in *hate*).
Iw or iw	"	" *you*.
Uo or ua	"	" wa (a in *fall*, *what*).
Ue or ue	"	" *way*.
Ui or ui	"	" *we*.
Uo or uo	"	" *woe*.

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1. The name by which the Ojibways or Chippewas call lake Superior is Kitchigumi, meaning great water.

2. Pigeon river is Omimi-zibi, Omimi meaning pigeon, and zibi — whenever it occurs — river. It can be written either zibi or sibi, but the former represents more accurately the sound.

3. The bay south of Pigeon river put down on the map as Waswaugoning bay is called by the Ojibways, *Wasswewini-wikwed*, making-a-light-by-torches bay, i. e. to catch fish by night.

4. Grand Portage bay is called Kitchi Onigum or great portage.

5. The river marked on the map as Maw-ske-qua-caw-maw is called Mesqua-tawangawi-zibi or Red Sand river; the Mesqua being "red," tawanga "sand," and the wi a connective.

6. Horse-shoe bay is Wiquedons. The Little bay, Wiquedonsing at or to the-little-bay.

7. Brule river is Wissakode-zibi or Half-burnt-wood river.

8. Devil-track river is Manido-bimadagakowini-zibi, meaning, the spirits or God walking-place-on-the-ice river.

9. Bay of Grand Marias is Kitchi-bitobig, the great duplicate-water; a parallel or double body of water like a bayou.

10. Poplar river is Ga-manazadika-zibi, i. e. place-of-poplars-river.

11. Cross river is Tchibaiatigo-zibi, i. e. wood-of-the-soul-or spirit river; they calling the Cross, wood of the soul, or disembodied spirt. This river is so called from a priest who long ago crossed from the south shore of lake Superior in the night and in the morning set up a cross there. The grandson of the woman who was with him in the canoe is my informant.

12. Manitou river is the same as above, Manido-bimadaga-kowini-zibi, there being two rivers of that name on the north shore of lake Superior.

13. Beaver bay is Ga-gijikensikag. The-place-of-little-cedars.

14. Split-rock river is Giniuwabiko-zibi; the-war-eagle-iron-river.

15. Gooseberry river is Shabonimikani-zibi;Gooseberry-place-river, or the-place-of-gooseberries river.

16. Encampment island is called "Miniss" or the island, that being the only one all along the north shore nearly to Pigeon river.

17. The bay opposite is called Minissing-Wiqued or the bay-at-the-island, or island-bay.

18. Silver creek is Shonia-zibiwishe, Silver creek.

19. Stewart's river is Bitobigo zibi, Parallel river, or Double river, no doubt from its flowing parallel to Silver creek.

20. Agate bay is Wasswewining, making-a-light-by-torches; i. e. to fish by night; ing is the termination at or to.

21. Knife river is Mokomani-zibi, Knife river.

22. Sucker river is Namebini zibi. Sucker river.

23. French river is Angwassago-zibi or Flood-wood river.

24. Lester river is Busabika-zibi. Rocky-cañon river, or the river-that-comes-through-a-worn-hollow-place-in the-rock.

25. Duluth is Onigumins, or the little portage, so called from their carrying their canoes over Minnesota point into the bay. Oniguminsing at or to Duluth.

Places on northern boundary going from lake Superior are as follows:

26. Moose lake, Mozo-sagaiigun. Sagaiigun, wherever it occurs, means lake and hereafter only the first syllable need be written, i. e., sag.

27. Pine lake, Shingwako-sag, Pine lake. Shingwak is a pine, o a connective vowel, sagaiigun lake.

28. Mountain lake, Gatchigudjiwegumag-sag. The lake-lying-close-by-the-mountain or Mountain lake.

29. Rove lake is Ga-wissakweagumag-sag. The lake-lying-in-the-burnt-wood-country.

30. Rose lake is Ga-bagwadjiskiwagag-sag, or the shallow-lake-with-mud-bottom.

31. Clearwater lake (near Rove lake) is Ga-wakomitigweiag-sag, or Clearwater lake.

32. Iron lake is Biwabiko-sag, Iron lake.

33. Gun-flint lake is Biwanago-sag, or Gun-flint lake.

34. Greenwood lake is Ushkakweagumag-sag, or Greenwood lake.

35. Saganaga lake is Ga-sasuganagag-sag, the lake surrounded by thick forests.

36. Bear-skin lake is Muko-waiani-sag, or Bear-skin lake.

37. Otter-track lake is Nigig-bimikawed-sag, the lake-where-the-otter-make-tracks. From four tracks of an otter on the rocks by the side of the lake, as if he had jumped four times there.

38. Knife lake is Mokomani-sag, Knife lake.

39. Cacacowabic lake is Kekekwabiko-sag, meaning hawk-iron-lake.

40. Bebiqwudjibiwudjissing-sag is the Ojibway name of Snow-bank lake. The word means the-snow-blown-up-in-heaps-lying-about-here-and-there-lake.

41. Basswood lake is Bassemenani-sag or Dried blue-berry lake.

42. Burnt-side lake is Ga-nubune-abikideagumag-sag. The lake-where-the-timber-has-been-burnt-off-on-one-side.

43. Long lake, Ga-shagawigumag-sag, long-narrow lake.

44. The large lake, about three miles northeast of Long lake, nameless on the map, is Ga-wassidjiwuno-sag,* or the lake-that-is-white-with-the-foam-of-the-rapids.

45. Birch lake is Ga-wigwassensikag umag-sag, Little Birch lake, or the-place-of-little-birches-lake.

46. Ka-wishiwi-river is correct; means The river-full-of-beaver's-houses; or according to some, musk-rats houses also.

47. Eagle's Nest lake, east of Vermilion lake, is properly Muko-minisiwi-sag; Bear-island lake.

48. Embarrass lake, St. Louis county is Gatitisawangidjiwung-sag. The-lake-with-the-sand-whirling-round-in-the-water-by-means of-the-current.

49. The nameless lake, north and a little east of Embarass, is Showiminabo-sag or Wine lake, literally Grape-liquid-lake.

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* Frank Blatchford, Chippewa interpreter at Ashland, Wis., writes this Gawasijiwang.—[N. H. W.]

50. Eshquaguma lake is Eshquegumag, Last-water-lake, or Last-lake.

51. St. Louis river is Kitchigumi-zibi, or lake Superior river.

52. The nameless lake on Partridge river is Bine-sag; Partridge lake.

53. Partridge river is Bine zibi; Partridge river.

54. Mesabi hights is missabe-wudjiu or Giant mountain.

[N. B.—Missabe is a giant of immense size and a cannibal. This is his mountain, consequently the highest, biggest mountain.*]

55. Cloquet river is Ga-bitotigweiag-zibi. The-river-that-runs-parallel-or-double; so called from running parallel with lake Superior, making a double with it.

56. Lake of the Woods is Babiquawanga. The-lake-full-of-sand-mounds-there drifted about like snow by wind.

57. Rainy lake is Kotchitchi-sag, meaning according to some, Neighbor lake, according to others a lake somewhere, (a difficult word.)

58. Rainy Lake river is Kotchitchi-zibi, meaning either Neighbor river or river somewhere, (not a strictly Ojibwe word.)

59. The river from Rainy lake up toward lake Superior is called Ga-manitigweia-zibi, or Bad-flowing-river.

[Here follow the names of some places beyond the boundary.]

60. White Fish bay is Ga-atikumegokag-sag, or White Fish lake.

61. Crow lake is Gagagiwi-sag. Raven lake.

62. Sabaskang bay is Shibashkang, "where they go winding about to find passage," among the islands.

63. From White Fish bay to Manito river, the river is called Ga-manitigweians, or The-little-bad-flowing-river.

64. The name of the river north of Hunter's island is called Ga-wasidjiwuni-zibi, or River-shining-with-foam-of-rapids.

65. Kabet-to-go-ma lake is Ga-bitogumag-sag, meaning The lake-that-lies-parallel-or-double, namely with Rainy lake.

66. Loon lake is Mango-sag, meaning Loon lake.

67. Lac-la-Croix is Sheshibagumag-sag. The-lake-where-they-go-every-which-way-to-get-through.

68. Vermilion lake, Onamuni-sag. Vermilion lake.

69. The nameless river running from Eagle's Nest lake to Vermilion lake is called Eshqueguma-zibi, or Last river, from the fact that it rises in Eshqueguma-sag or Last lake, which is not

*The Chippewas at Grand Portage represent Missabe as entombed in the hills near there; the various hills representing different members of his body.—[N. H. W.]

named on the map but is the next lake to Birch lake and north of west end of same.

[N. B.—Rivers are by the Ojibways nearly always named from the lakes, out of which they flow as in this instance.]

70. Net lake is Asubikone-sag, meaning Taken-or-entangled-in-the-net-lake.

71. The river flowing from Net lake is called Ningotawonaning or Separating-canoe-routes-river from the river forking. "Ing" is the termination at or to.

72. Big-fork river is called Atchabani-zibi or Busatchabani-zibi. Bowstring river; so called according to the usual rule from rising in Bowstring lake.

73. Bowstring lake; Atchabani-sag, or Busatchabani-sag; (it is pronounced both ways by different Chippeways), meaning Bowstring lake.

74. Little Fork river, Ningtawonani-zibi; Separating-canoe-routes-river, as explained above, No. 71.

75. Round lake, northwest of Bowstring, is Ga-wawiiegumag-sag. Round lake.

76. Big White-face river is Kitchi-wabishkingwewe-zibi. Big white-face river.

77. Ushkabwahka river is Ushkibwakani-zibi. The-river-of-the-place-of-the-wild-artichokes.

78. East Savanna river, Mushkigonigumi-zibi. The-marshy-portage-river; from the marshes or low lands bordering the river, making the portages over marshy ground.

79. East Swan river, tributary of the St. Louis, is Wabiziwi-zibi. Swan river.

80. Grand lake, near St. Louis river, is Kitchi-sagaiigun; or Grand lake.

81. Canozia lake is Ga-ginogumans-sag, or Little Long lake.

82. Wild Rice lake, back of Duluth, is Megwewudjiwmanominikan. The-place-of-wild-rice-amidst-the-hills.

83. Prairie lake is Mushkodensiwi-sag, or Little Prairie lake.

84. Prairie river is Mushkodensiwi-sibi, or Little Prairie river.

85. Minnesota point (at Duluth) is Shagawamik, meaning the long-narrow-point; "ing" to or at the long narrow point, as usual.

86. Rice's point — near Duluth within city limits — Wubishingweka, meaning the narrow contraction (of the river) caused by the point covered with little pines.

87. Fond-du-Lac is Nagadjiwanang, where the flow of the water stops or is arrested; "ang" the usual termination to or at.

88. Dalles of the St. Louis from Thompson down. Kitchi Kakabikang; the great fall,—"ang" at or to.

89. Sandy lake, Aitkin county. Ga-mitawangagumag-sag. Referring to the character of the soil in which the lake is situated. The-place-of-bare-sand-lake, or Sandy lake.

90. Perch lake on N. P. R. R. near Junction; Atawemegokag-sag. The-place-where-the-fish-fire-goes-out-lake, that is the place where the fishes die for want of air, being in too shallow a place, and freezing up.

91. Knife falls. Mokomanonigum. Knife portage.

92. Island lake, N. P. R. R. Ga-minisiwung-sag. Island lake.

93. Rice lake, south of Sandy lake, Kitchi-manominikani-sag. The-great-place-of-wild-rice-lake.

94. Willow river (east of Mississippi nearest Aitkin), Moinujewi-zibi, meaning Dung-on-the-skin-river.

95. Wakonabo-sag. The lake of the broth of Wakwug or fish-melt, or eggs-broth-lake; or Broth-of-moss-growing-on-rocks-or-trees-lake.

[N. B.—The Indians use the latter in case of starvation. Both the above explanations are given by different Indians.]

96. Moose river is Moz-oshtigwani-sibi; or Moosehead river.

97. Moose river heads in some little lakes called Nodaishibaning; or The-place-of-hunting-ducks-lakes.

98. Willow river, north of Moose river, is Ozisigobimiji-zibi.

99. Hill lake is Pikwudina-sag, or Hill lake.

100. Nameless lake south of Pokegama and about six miles west of the Mississippi is called Ushigunikan-sag, meaning Bass lake or The-place-of-bass-lake.

101. Prairie river on Mississippi is Mushkodensiwi-zibi, or the river of the little prairies. Little Prairie river.

102. The lake on the above river is the same, Mushkodensiwi-sag, or Little Prairie lake.

103. Trout lake, Namegosi-sag. Trout lake.

104. Swan river, east of last, is Wabiziwi-zibi, or Swan river.

105. Deer lake north of Pokegama is Wawashkeshiwi-sag, or Deer lake.

106. Trout lake, north of above, is Namegosi-sagaiigun, or Trout lake.

107. Spider lake, north of above, is Asubikeshi-sagaiigun.

108. Stephens lake is Wawashkeshiwi-sag, or Deer lake.

109. Ball-club lake is Pagantowan, or Ball-club lake, being the instrument they hold in their hand and play with, the game of La-Crosse.

110. Bass lake (south of Deer lake) Ushigunikan-sag. The-place-of-bass-lake.

111. Mud lake (on Leech lake river). Ga-bagodjishkiwugag-sag, meaning shallow-mud-bottomed-lake.

112. Quaim-butch-e-weg-e-mug south of Pokegama lake, is Ga-wimbudjiwegumag. The-lake-that-lies-in-the-hollow-of-the-mountain.

113. Sinzi-ba-quat-sag, west of last, is correct, means sugar lake.

114. Vermilion lake, above lake Pokegama, is Onamuni-bigokag-sag, meaning Vermilion lake.

115. Nameless lake, long shaped, between Leech lake river and Winnibigoshish lake, is named Kitchi-bugwudjiwi-sag, meaning big-lake-in-the-wilderness or big-wilderness-lake.

116. Winnibigoshish is correct; means miserable-wretched-dirty-water, (Winni, filthy; bi, water; osh, bad, an expression of contempt; ish, an additional expression of contempt, meaning miserable, wretched).

117. The promontory on west shore of Winnibigoshish is named Gagagishibeneashi, or Raven-Duck point. The stream that comes in there has same name.

118. The nameless lake, west of Winnibigoshish, is Bitowi-manominikan-sag. Parallel-rice-field-lake, or Double-rice-field-lake.

119. Cass lake is Ga-misquawakokag-sag, or The-place-of-red-cedars-lake, from some red cedars growing on the island; more briefly Red Cedar lake.

120. The large island in the lake was anciently called Gamis-quawako-miniss, or the island of red cedars. It is now called Kitchi-miniss or Great island.

121. The little pond, nameless on the map, two miles south of the extremity of lake Itasca, from which the farthest drop of water comes to the Mississippi, has no name given to it by the Indians; it was first named by the writer lake Whipple in honor of the first bishop of Minnesota.

122. Elk lake — on the map so called — separated from lake Itasca by a narrow piece of land and south of same is called by them Pekegumag-sagaiigun. The-water-which-juts-off-from-an-

other-water. It was first named by the writer Breck lake, in honor of the distinguished first missionary of the American church to St. Paul and vicinity, who was afterwards first missionary of the church to the Chippewa Indians around the sources of the Mississippi.

122½. The river (nameless on the map) running from above lake is Pekeguma--sibiwishi, or brook-of-the-water-which-juts-off-from-another-water.

123. Itasca lake has been called by the Indians, from time immemorial, Omushkozo-sagaiigun; Elk lake.

124. The Mississippi running thence is called Omushkozo-sibi from lake Itasca till it reaches the lake.

125. Lake Bemidji is Bemidjigumag-sagaiigun, or the lake where the current flows directly across the water, referring to the river flowing squarely out of the lake on the east side, cutting it in two as it were. Very briefly Cross lake. The-lake-where-the-current-flows-directly-across-the-water.*

126. From lake Bemidji to Cass lake the river is called Bemidjiguma-sibi, or Cross river.

[For fuller descrption see No. 439.]

127. From Cass lake to Winnibigoshish it is called Ga-misk-quawakoka-zibi; Red Cedar river, or river of the place of red cedars.

128. From outlet of Winnibigoshish to mouth of Leech Lake river it is called Winnibigoshish-zibi; Winnibigoshish river.

129. Below the junction of Leech Lake river it is called Kitchi-zibi, or Great river.

[N. B.— I can not find by inquiry that the Chippewas have ever called it Missizibi (Mississippi) or Missazibi. But I consider it very probable that in remote times they did, for Missa-zibi (Mississippi) would express the same idea in their language, and would be proper, as witness Missa-sagaiigun (Mille Lac) meaning Great lake. It so exactly corresponds with their language that it must have been taken from it.]

130. Upper Rice lake—on the map—northwest of lake Itasca, is Ajawewesitagun-sag, meaning the lake where there is a portage from water running one way to waters running the opposite way, or briefly, Hight-of-land-lake.

131. Red lake is Misquagumiwi-sagaiigun. Red-water lake, so called perhaps from a sort of reddish, fine gravel or sand along the shore in places, which in storms gets wrought into the water near the edges. By others so called from being sometimes of a

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* Others interpret it as meaning the same as the French *Travers*, i.e., where it is necessary to go directly across the body of the lake in passing up or down the Mississippi.—[N. H. W.]

reddish color from streams running from the bogs north of the lake, the water from which streams is of a reddish color.

132. Red Lake river is Misquagumiwi-sagaiiguniwi-zibi (Red-Lake river) to Red river.

133. The narrow point of land running west in Red lake, dividing it almost into two, is called Wabashi-ing at or to Wabashi. Wabashi means the straits; something contracted.

134. Crookston on Red Lake river is called Asadi-minaqwam. The-poplar-grove.

135. Roseau river in Kittson county is Ga shashagunushko-kawi-sibi, or the-place-of-rushes-river, or briefly, Rush river.

136. The next river south, namely Two Rivers, is Ga-nijoshino-zibi, or the-river-that-lies-two-together-as-in-a-bed; no doubt, from its two branches running parallel.

137. Tamarack river is Ga-mushkigwatigoka-zibi, Tamarack river.

138. Snake river, next south, is Ginebigo-zibi, Snake river.

139. Sand Hill river is Ga-papiqwutawangawi-zibi, or the-river-of-sand-hills-scattered-here-and-there-in-places.

140. Clearwater river, Polk county, is Ga-wakomitigweia-zibi, or Clearwater river.

141. The South fork of Clearwater river is peqwudina-zibi, Hill river.

142. The lake, nameless on map, in which the above South fork of Clearwater river rises is Ajegunegamga-shingwakokag-sag, the-lake-with-pines-on-one-side-of-the-water.

143. The lake, nameless on map, southwest of last, is called Mekinako-sag, or Turtle lake, from its form, which, seen from a canoe in the middle, closely resembles a turtle.

144. Poplar river, Polk county, is Asadi-zibi, or Asadikawi-zibi; the former meaning poplar river; the latter Place-where-poplars-are river.

145. The river, nameless on map, south of South fork of Clearwater and running into Clearwater river, is Kitchi zibi-wishi, or Big brook.

146. The lake, nameless on map, south of source of last-named creek, and near the present town of Fosston, Polk county, is Pugwundumokan-sag, or the-place-of-suffocated-fish lake, that is, where the fishes die for want of air, and are seen dead.

147. Middle river, Marshall county, is Nessawitigweia-sibi, or Midde-flowing river.

148. Wild Rice river is Ga-manominiganjikawi-zibi. The-river-where-wild-rice-stalk or plant is growing; so called from the last lake through which it flowed.

149. The south branch of Wild Rice river is Ga-tchekatigweia-zibi, or Ga-tchatchwequatigweia-zibi. The-river-that-thrusts-into-something-and-disappears; referring to its sinking into the ground and disappearing for some time.

150. The large lake, nameless on map, called Maple lake by the whites, near Maple bay and Mentor, Polk county, is Ga-shabwewegumag, meaning the-lake-that-forces-itself-through-the-timber-in-a-long-bay.

151. Thief river is Kimod-akiwi-zibi. The-stolen-land-river or Thieving-land-river. For the meanings see Warren's History.

152. Elbow lake, in which the Red River of the North rises, is Ga-odoskwunigumag, or Elbow lake.

[N. B.—The little pond six miles N. E. of it, from which a little stream comes and which may be called the source of the river, is unnamed by the Indians.]

153. The river coming from Elbow lake is called Ga-odoskwuniguma-zibi, or Elbow Lake river, according to the usual rule.

154. Many-point-lake, Ga-muminewamiwung-sag. The-lake-with-bays-running-in-all-directions is next on stream.

155. The river running out of above lake is according to usual rule, Ga-muminewami-zibi. Bays-in-all-directions river.

156. The next lake, nameless on map, three miles southwest of last and of long shape, is Ga-wawunokag-sag, or the-place-of-eggs lake.

[N. B.—There are a number of smaller lakes there. They are all called Egg lakes.]

157. The river thence to next lake is Ga-wawunoka-zibi, or Egg river.

158. The next lake, the large one, nameless on map, east of Flat lake, is Ga-bagwag, or Shallow lake.

159. The river, nameless on map, flowing thence is called Ga-bagwag-sibins, or Shallow-lake-little river until it is joined by the Round Lake river.

160. The next lake, nameless on map, through which it flows is the small lake north of Hight-of-Land lake named Assig-inako-manominikani-sag, or the-blackbird-place-of-wild-rice lake.

161. The river flowing thence is Assiginako-manominikani-zibi, or the black-birds-place-of-wild-rice river.

162. Hight-of-Land lake, the next, is Ajawewesitagun-sag, the lake-where-the-portage-is-across-a-divide-separating-water-which-runs-different-ways, or Hight-of-Land lake.

163. The river flowing thence has the same name, Ajawewesitagun-zibi or Hight-of-Land river.

164. The next lake is a little one, south of Frazee City — nameless on map — called Manominikan-sag or the place-of-wild-rice lake, but the river still retains its former name of Ajawewesitaguni-zibi to the next lakes. Twin lakes.

165. Little Pine lake and Pine lake are called Ganijogumag-sag, or Twin lakes.

166. The river issuing thence is called Ga-nijoguma-zibi, or Twin Lake river till it enters Rush lake.

167. Rush lake is Ga-shashagaunushkokag-sag, the place-of-rushes lake.

168. The river issuing thence is called Ga-shashagunushkaka-zibi till Otter Tail lake.

169. Otter Tail lake is Nigigwanowe-sag. Otter-tail lake.

170. The river issuing thence is called Nigigwanowe-zibi, till its junction with the Bois de Sioux river, notwithwstanding it passes through.

171. A lake, nameless on the map, close to Otter Tail and southwest of same, called Wawashkeshiwi-sag. Deer lake.

172. The next lake it flows through is Ga-wimbudjiuwegumag-sag, or the-lake-that-lies-in-the-hollow-of-the-mountain.

173. Red River of the North from its junction with Bois de Sioux river is called by the Ojibways simply Kitchi-zibi. Great river.

174. Lake Travers is Ga-edawaii-mamiwung-sag. The-lake-with-a-breast, or pap (like a woman's) on either end; one on the northern, and one on the southern; (flowing into Big Stone lake in high water); so flowing either way.

175. Bois de Sioux river is Ga-edawaii-mami-zibi, or the-paps-on-either-end-river.

Names of the rivers on west bank of Red river from north to south are as follows:

176. Pembina river, Anibinani-zibi, meaning the-high-bush-cranberry-river.

177. Tongue river is Odenaniwi-zibi. Tongue river.

178. Park river is Shiwitaguni-sibins. Little Salt river.

179. Forest river, Shiwitaguni-zibi. Salt river.

180. Grand Forks, Kitchi-madawang. The big forks; that is where the rivers are so large in either fork that you don't know which to go into.

181. Turtle river, Mikinako-zibi. Turtle river.

182. Goose river, Niki -zibi.

183. Elm river, Anibi-zibi.

184. Maple river, Ga-ininatigoka-zibi. Place-of-maples-river.

185. Cheyenne river, Ga-ninaweshiwi-zibi. The-river-of-the language-that-we-almost-understand. That is what they call the Cheyenne Indians. Ga-ninaweshiwug.

186. Wild Rice river, Ga manominiganjikani-zibi. The river where the wild rice stalk or plant is growing.

187. Rush river, Ga-shashaganushkokani-zibi. Rush river or the-river-of-the-place-of-rushes.

188. White Earth lake, Ga-wababigunikag-sag. The-place-of white-clay-lake; so called from the white clay which crops out in places at the shore of the lake.

From the lake is taken the name of the reservation and adjoining region.

189. White Earth river, named from the lake, is Ga-wababigunika-zibi. White Earth river, according to usual rule named from the lake.

190. Tuliby lake, Ga-odonibinsikag-sag. The-place-of-tulibies-lake.

191. The river running thence to next lake is Ga-odonibinzikag-sibiwishi. Tuliby creek.

192. The nameless lake down the stream and northeast of White Earth lake is Shushuginsikan lake, or the-place-of-young-herons-lake.

193. The river flowing thence is Shushuginsikani-zibins, or the-place-of-young-herons-little-river.

194. Twin lakes, eighteen miles N. E. of White Earth on road to Red lake, Ga-nijogumag. Twin lakes.

195. The river thence flowing, Ga-nijo-gumag-sibiwishe. Twin lakes creek.

196. Strawberry lake, Ga-odeiminikag-sag. The-place-of-strawberries-lake.

197. Round lake, Ga-wawiiegumag-sag. Round lake.

198. Lake — nameless on the map — one mile south of Round lake, Ga-nita-mumudweqwuding-sag. The-lake-which-keeps-cracking-and-roaring-with-the-cold.

199. The lake — nameless on the map — directly N. E. of Strawberry lake, is Ga-wajushkokag-sag. The-place-of-muskrats-lake.

200. The lake — nameless on the map — between Round lake and Shell lake just south of road to Leech lake, is Ga-shagawigumag. The-long-narrow-lake.

201. The large lake, nameless on the map, three miles north of

Shell lake, is Ga-kitchigumiwushkokag-sag, meaning the-lake-of great-rushes, (the kind out of which the Indians make their rush mats.)

202. The large lake, not down on map, 28 miles S. W. of Red lake on road to same, is Nio-gade-sag, or four-legged lake; from an old Indian of that name who lived there.

203. The large lake, nameless on map, 18 miles S. of Red lake, near road to White Earth is Ga-wakomitigweia-sag. Clearwater River lake.

204. . Shell lake, Becker county, is Ga-tchigudjiwegumag-sag. The-lake-lying-near-the-mountain.

205. Shell river flowing from above is Ga-tchigudjiweguma-zibi. Mountain Lake river.

206. The lake, nameless on the map, about nine miles directly southwest of Elk lake, so called, is Ga-wigobi-minising or bass-wood-little-island-lake.

207. Toad lake is Mukuki-sag. Toad lake.

208. Toad river is Mukuki-sagaiiguniwi-zibi. Toad lake river.

209. Lake Colton or Cafton, south of Tamarack lake, is Ga-minisabikowung-sag. The-lake-with-the-rocky-island.

210. Tamarack lake is Ga-mushkigwatigokag-sag, or the-place-of-tamaracks-lake.

211. Flat lake is ———

212. Straight lake, Ga-gwaiukwitgweiag-sag. Straight-flowing-lake.

213. Straight river, Ga-gwaiukwitigweia-zibi. Straight-flowing-river.

214. Buffalo lake, Becker county, is Obiningutoway-sag. The lake-where-it-keeps-crumbling-away-from-the-beaver's-gnawing.

215. The river flowing thence, on map Buffalo river, is Obiningutoway-zibi. The-river-where-it-keeps-crumbling-away-from-the-gnawing-of-beavers.

216. The river — nameless on map — which comes from Audobon and flows into the above is called Pijikiwi-zibi, or Buffalo river, from the fact that buffaloes were always found wintering there. Hence the white people have erroneously called the whole river Buffalo river.

Source and course of the Pelican river.

217. Lake Gilchrist is Nishiwe-sag. All-murdering-lake.

218. The stream thence is called Nishiwe-sagaiiguniwi-zibi-wishe or murdering-lake-creek, to Floyd lake.

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219. Floyd lake is Migizi-wuziswuni-sag, or Eagle's Nest lake.

220. The creek thence flowing is Migizi-wuziswuni-zibiwishe, or Eagle's-Nest-creek.

221. Next lake, nameless on map, is Manominiganjiki-sag — north of Detroit — the-lake-in-which-wild-rice-grows, or wild rice field lake.

222. The creek thence flowing is Manominiganjiki-zibiwishe. Rice-growing-creek, to Detroit lake.

223. Detroit lake is Ga-ajawaangag-sag. The-lake-in-which-there-is-crossing-on-the-sandy-place.

224. The river flowing thence. marked on some maps Pelican river, is Ga-ajawaanga-sibiwishe, or Detroit-lake river.

225. The next two lakes, on some maps called lakes Sully and and Amelia, are Ga-nijo-gumag. Twin lakes.

226. The next lake, nameless on any map, through which the river flows, a small one, is called Ga-bi-midji-sagitawag sag, or The-lake-which-is-squarely-flowed-across (by the river) at its outlet.

227. The next. Pelican lake, on map, through which the river runs, is Ga-pushkodewegumag-sag. The-lake-with-the-smooth-shorn-prairie-coming-down-to-it-on-one-side.

228. Lake Lida, as it is put down on the map, the next through which the river runs, is Shede-sagaiigun-ajawakwa, Pelican-lake-beyond-the-timber, to distinguish it from the other Pelican lake.

[N. B.—Both parts of this great lake, separated by a narrow causeway over which a road now runs, are called by the same name, Pelican lake.]

(229 is wanting.)

230. The river flowing thence is called Shede-sagaiiguniwi-zibi, or Pelican-lake river.

231. Prairie lake is Oobe-sag. Oobe lake, from an old Indian of that name killed there by Sioux.

232. Fergus Falls is Kakabikans. The-little-squarely-cut-off-rock, or little fall.

233. The lake, nameless on the map, southwest of White Earth lake, on right hand of road leading to Leech lake, is Pugitawewin The-place-of-setting-nets.

234. The lake — nameless on map — 6 miles south of lake Itasca, has no distinctive name given to it; is called merely Sagaiigun. The lake.

235. The lake — nameless on map — 12 miles south of lake

Itasca, is Tchigudjiwegumag-sag. The-lake-lying-along-by-the-mountain.

236. Fish-Hook lake is Pugidabani-sagaiigun. Fish-hook lake.

237. The lake — nameless on map — just north of Fish-hook, is Ga-nijo-sagiwung. The-lake-with-two-outlets.

238. The river flowing south from Fish-hook lake is Pugidabani-zibi. Fish-hook river.

239. Pine river on Mississippi is Shingwako-zibi, or Pine river.

240. White Fish lake in same locality is Ga-atikumegokag-sag. The-place-of-white-fish-lake.

241. Cross lake, S. E. of White Fish, is Ga-bimidjigumag-sag. The-lake-which-the-river-flows-directly-across.

242. Daggett Brook lakes are Tchigawe-sag. Cutting-the-hair-off-the-skin-lakes.

243. Crooked lake is Wewagigumag-sag. Crooked lake.

244. The lake, nameless on map, just east of Crooked lake, almost touching it, is Buke-sagitawag. A-lake-forming-the-arm-of-river.

245. The next lake, nameless on map, northeast of last, is Ga-shagawigumag-sag. The-long-narrow-lake.

246. The next, nameless on map, is Manominiganji-kans. The little-place-of-wild-rice-growing-lake.

247. The little lake, nameless on map, between White Fish lake and Cross lake, is Shingwakosagibid-sag. The-lake-of-the pine-sticking-up-out-of-the-water.

248. The first enlargement on Pine river proceeding from the Mississppi is Bukweiawibia, meaning an enlargement-of-the-river.

249. The next is Ga-bagwag-sag. The shallow lake.

250. Norway lake is Ga-tchibo-sagitawag. The-lake-where-the-river-goes-quartering-across-it-diagonally, not straight.

251. Pine lake on Leech lake road is Ga-tchigudjiwegumag-sag. The-lake-lying-near-the-mountain.

252. The lake — nameless on map — two miles east of last is Manominiganijikans. The-little-place-of-wild-rice.

253. The next lake east — nameless on the map — is Mukundiwi-sag. Plundering lake; no doubt from the pillage which once took place there, from which the Pillagers took their name, as recorded in Warren's History.

254. Lake Lottie is Metawanga-sag. Sandy-beach lake.

255. The lake — nameless on the map — two miles N. W. of lake Lottie is Iquewi-sag. Woman lake.

256. The lake — nameless on the map — two miles N. W. of last is Wibogijigikag-sag. Cedar-narrows lake.

257. Woman lake is Iquewi-sag. Woman lake.

258. Little-boy lake is Quiwizensiwi-sag. Boy lake.

[N. B.— The last two named are so called from women and boys respectively, they having been killed in those lakes by the Sioux during an irruption made by them.]

259. The lake — nameless on the map — south of Boy lake is Wabuto-sag, or Mushroom lake.

260. Boy river is Quiwizensiwi-zibi. Boy river.

261. The enlargement on Boy river is Manominiganjiki, or The-rice-field.

262. Boy lake, next to Leech lake, is Quiwizensiwi-sag. Boy lake.

263. The spur of a lake, nameless on map, running S. E. from Boy lake is Ningitawonan-sag. Separating-canoe-route-lake.

264. The lake, nameless on map, in which the last mentioned heads is Mikinako-sag. Turtle lake.

265. Two little lakes, on thread of above stream, before coming to Turtle lake, nameless on map, are Mushkigwaguma. The Swampy lakes.

266. Big Rice lake, in which heads Willow river, is Nodaishiban, meaning the-place-of-hunting-ducks, i. e. from the multitude of ducks going there to eat wild rice.

267. Leech lake is Ga-sagasquadjimekag-sag. The-place-of-the-Leech-lake; from the tradition that on first coming to it, the Chippeways saw an enormous leech swimming in it.

268. Ten-mile lake, Namegosi-sag. Trout lake.

269. The large promontory in Leech lake stretching N. E. toward Cass lake is Shingwakoneashi, or Pine point.

270. The lake — nameless on map — directly south of Ten-mile lake is Ga-wigwasensikag-sag. The-place-of-little-birches-lake.

271. Long lake, south of Frazee City, is Ga-gawandjikag-sag. Juniper lake.

272. The lake, nameless on map, north of last is Ga-ishwassomikwed-sag. Eight-beaver lake.

273. The two little lakes east of last are called Manido-sag-aiiganun. Spirit or God lakes.

274. The somewhat large lake east of Frazee City and north of the Northern Pacific railroad is Ga-ajawitawangans-sag. The-lake-with-a-little-crossing-on-bar-of-land-across-it.

275. The lake, nameless on map, west of Otter Tail lake, north part, is Ga-bitawigumag-sag. Parallel lake or Double lake, from its lying parallel or double with Otter Tail lake.

276. The lake S. W. from Leaf lake, marked lake Godard on maps, is Ga-ajawaangans-sag. The-lake-with-the-crossing-on-a-spit-of-sand, so named from the little portage of sand from it into Leaf lake.

277. Leaf hills are Gaskibugwudjiwe. Rustling-leaf-mountain.

278. Leaf lake, Gaskibugwudjiwe-sag, or Rustling-leaf-mountain lake.

279. Leaf river, Gaskibugwudjiwe-zibi. Rustling-leaf-mountain river.

280. Partridge river isBine-zibi. Partridge river.

281. Battle lakes are Ishkwunidiwini-sag. Mutual-extermination lakes.

[N. B.—A great slaughter of Chippeways by Sioux took place there many years ago.]

282. Lake Clitheral, Gagawandjikag-sag. Juniper lake.

283. Lake Stellar in Tordenskjold township, Otter Tail county, is Odadjigaoni-sag. Garfish lake.

284. The river coming from last is Odàdjigaoni-zibi. Garfish river.

285. Lake Christianson is Ga-wubatawangag-sag. The-lake-with-the-contracted-place-formed-by-an-isthmus-of-sand.

286. Lake Pomme de Terre is Opinikani-sag. The-place-of-wild-potatoes-lake.

287. The river running from same is called Opinikani-zibi The-place-of-wild-potatoes-river.

288. Two Elbow lakes, southwest of Pomme de Terre, are Ga-odoskwunigumag-sag, or Elbow lakes.

289. The lake — nameless on map — in Eagle Lake township is Migizi-wuziswuni-sag. Eagle's Nest lake.

290. Osakis lake is Osagi-sag. The Sauk's lake.

291. Crooked lake near Osakis, Wewagigumag-sag, i. e. Crooked lake.

292. Sauk lake is Kitchi-o-sagi-sag. The great lake of the Sauks.

293. Birch bark-fort-lake, Ga-wigwassensikag-sag. The-place-little-birches lake.

294. Long Prairie river, Ga-shagoshkodeia-zibi. Long-narrow-Prairie river.

295. Sauk river, Osagi-zibi. The river of the Sauks.

296. Minnesota river, Ushkibugi-zibi. Greenleaf river.

297. St. Paul, Ushkibugi-zibi. Greenleaf river.

298. Minneapolis, Kitchi-kakabika. The Great Fall; very literally, the great squarely-cut-off rock.

299. Gull lake, Ga-gaiashkonzikag-sag. The-place-of-young-gulls lake.

300. Round lake, Ga-wawiiegumag-sag. Round lake.

301. Cubert lake, Ga-manominiganjikag-sag. Wild-rice lake.

302. The northern prolongation of Gull lake is called Ga-ginogumans. The-little-long lake.

303. Crow Wing river, Gagagiwigwuni-zibi. Raven-feather-river.

304. Nameless lake—on map—7 miles N. W. of Park Rapids, Hubbard county, called by whites, Elbow lake, is Ga-adjudjequatigweiag-sag, means very literally, "The-lake-into-which-the-river-pitches-and-ceases-to-flow;—dies there." (That is, it has no outlet.)

305. Mille Lac lake, misa-sag. An Archaic word meaning every-where lake or Great lake.

306. Crow Wing village, Ningitawitigweia. The-forking-of-the-rivers.

307. Gull river, Ga-giashkonsika-zibi. Gull river.

308. Nokesippi is Noke-zibi. Noke's river.

[N. B.—Noke is a man's name, found only among the dodem or Clan of the Bears, so this means "the dodem of the Bear's river."]

309. Lake Alexandria near Fort Ripley, Shumano-sag. From an old Indian named Shumanons, who lived there long ago, from whom the Indians named the lake.

310. Little Elk river, Omushkozo-zibi. Elk river.

311. The prairie north of Belle Prairie, where the railroad runs along the river—Tchi-kishkutawangag. Meaning Big-cut-sandy-bank-place.

312. Little Falls, Kakabikans. The Little fall.

313. Swan river, Wabiziwi-zibi. Swan river.

314. Two-rivers, Ga-nijotigweiag-zibi. Two-flowing-rivers.

315. Long lake on Nokezippi, Gaginogumag-sag. Long lake.

316. Round lake; small lake down the stream, Noke-sag. Noke lake.

317. Platte lake, Pequishino-sag. Hump-as-made-by-a-man-lying-on-his-hands-and-knees-lake.

318. Platte river, Pequishino-zibi. Hump-as-made-by-a-man-lying-on-his-hands-and-knees-river.

319. Small lake — nameless on map —at Gravelville, Nisawudina-sag. Lake-in-the-midst-of-mountains.

320. Little Rock river — Piquabika-zibi, Little Rock river, meaning the river where the little rocky hills project out every once in a while, here and there.

321. Sisseton Agency, Dak. Ter., Ogimawudjiu, or King mountain.

322. Frazee City, Minn., Ga-shabwakwumok. Where-the-road-passes-out-of-the-timber.

323. Lake — nameless on the map — north of Manter, Hubbard county, Ga-ogikutanangokag-sag. The-place-of-the-lizards-lake.

324. Red Eye river — Miskoskindjigo-sibi. Red Eye river.

325. Lake — nameless on map — 8 miles directly west of 10-mile lake, Ga-ajogune-mushkodewung-sag. The-lake-with-prairie-on-one-side.

326. Shingobi minisensiwi-zibi, a river running into Leech lake, is correctly named; means Little-balsam-island river.

327. The lake — nameless on map — 3 miles west of that river, being the first from Leech lake, is Ga-ginogumag-sag. Long lake.

328. The next is Ga-onamunikag-sag. Vermilion lake.

329. Kabekuna lake is correct — means The-end-of-all-roads lake.

330. Niki-miniss is Goose island in Leech lake; correct.

331. Bear island is Muko-miniss; correct.

332. Pelican island is Shede-miniss. Pelican island.

333. The point — nameless on map — running south into the centre of Leech lake is Nigigwanow. Otter Tail.

334. Grand Rapids, below Pokegama fall, is Ga-ganwadjiwanang. The-long-rapids.

335. White Oak point is Nemijimijikan. White Oak point.

336. Pelican lake, north of Gull lake, Shede-sag. Pelican lake.

337. Pike lake, near Mille Lac, Wijiwi-sag. The-lake-full-of-muskrat-houses or beavers.

338. Heron lake, north of Mille Lac, Pepiqueweg-sag, Echo-lake, means where the sound of a call returns in an echo.

339. Mud lake, Pepushkodjishkiwugag-sag, means Thick-mud but smooth as it were shorn lake.

340. Cedar lake — near Aitkin — Ga-misquawakokag-sag. Red Cedar lake.

341. Serpent lake, Newe-sag. Blow-snake lake.

342. Rabbit lake, Wabozo-wakaiiguni-sag. Rabbit's-House lake.

343. Ogeshie lake, the nearest outlet of Mille Lac, is Netumigumag, meaning First lake.

344. Nessawe — next lake on river — is Nessawegumag. Middle lake.

345. Onamuni lake is Eshquegumag. The last lake.

346. Rum river is Missa-sagaiiguniwi-zibi. Mille Lac lake river, literally Everywhere-lake river.

347. Princeton is Ningitawitigweiang. The-place-where the-rivers-fork.

348. Hanging Kettle lake is Akik-agodjina-sag. Hanging Kettle lake.

349. The lake — nameless on map — just east of the middle of Mille Lac and very near to same is Mishidonshi-wakaiiguni-sag. The miserably-bearded-one's-house-lake. This is so-called from a Frenchman, a trader *with a thin straggling beard*, who had his trading-post at this lake.

350. Skunk river is Shingwakozowe-zibi. Pine-tail river.

351. The island in S. W. part of Mille Lac is Kitchiminiss. Big island.

352. The small, three-pronged lake — nameless on map — S. W. of trading post at N. E. corner of Mille Lac, is Pupushqua-minissensiwi-sag. The-little-shorn or cleared island lake.

353. Island — nameless on map — in Leech lake on way to Cass lake is Ajawiu.

354. Lake — nameless on map — the first out of Leech lake on way to Kabekona, is Wubitigweia-sag. The-lake-made-by-a-contraction-of-the-flowing of the river.

355. The lake — nameless on map — to the southwest of last and very close to it, is Ga-ajawush-quagumag-sag. Green-water lake.

356. The river extending N. W. is Kabekona-zibiwishe. The-end-of-all-roads creek.

357. The name of the river extending from Leech lake up to steamboat landing is Ga-misqua-wakokag-sibiwishe. Red Cedar brook or creek.

358. The lake — nameless on map — lying nearly due west from end of the last river, is Ga-buke-sagitawag. The-lake-forming-an-arm- (or outburst) of-a-river.

359. The river — nameless on map — running out of last

named lake N. W. toward Bemidji lake, is Ga-gibinewenitizo-zibi. The-river-where-the-person-hanged-himself.

360. The lake whence the above river issues — perhaps called lake Grave on map — is Ga-gibinewenitizo-sag. The-lake-where-the-person-hanged-himself.

361. Dead lake near Otter Tail lake is Tchibegumigo-sag, or House-of-the-Dead-lake.

[N. B.— A grave is called house of the dead, from the custom of the Indians to build the resemblance of a little house over a grave.]

362. The river issuing from said lake is Tchibegumigo-sibiwishe, or House-of-the-Dead-creek.

363. Star lake is Shede-sag-nawakwag. Pelican-lake-in-the midst-of-the-timber.

[N. B.— The above named Pelican lakes were all called so from being covered with Pelicans in old times.]

364. Brainerd is Oski-odena. Newtown.

365. Where the Roman Catholic church is, above Little Falls is Kitchi-kitiganes. The-great-little-field.

366. The German village, a little higher up the river than Gravelville lake, on Platte river is Babik-wajibikang. The-place-where-the-rocky-strata-underneath-keep-cropping-up in the rocky mounds scattered here and there.

367. St. Cloud is Sagi-zibi. The Sauk's river.

368. The Trading Post below Mille Lac, Kibakwaiigun. The Dam.

369. Cormorant lake, Becker county, is Ga-gagishibensikan. The-place-of-little-Cormorants, i. e., from their nesting there.

370. Little Cormorant lake is Ga-shishibagumag-sag. The-lake-which-runs-every-which-way.

371. The lakes at Lake Park—nameless on map—are Newadinibugansing-sag, meaning, the-lakes-where-there-are-streams-groves-prairies-and-a-beautiful-diversified-park-country.

372. Lake Eunice, Becker county, is Ga-gibishe-sag. Deaf lake.

373. The somewhat large lake — nameless on map — up the stream from Dead lake and about two miles west is Wejawushquagumi-sag, or Lake-with-the-water-green-as-grass, from the intensely green color of its water.

374. The good-sized lake in Norwegian Grove township — nameless on map — is Bimadagutchigun-sag, or Driven-to-bay-in-the-water-lake, from the Sioux having once at that place suddenly attacked the Chippeways, who rushed into the water to

escape from their enemies, who took the Chippeways' own canoes, followed them into the water and cut off the heads of many of them defenselessly there.

375. The lake—nameless on map—two miles to the north of the last is Ga-minissiwung-sag, or Island lake, from its islands.

376. A little lake—nameless on map—south of Otter Tail river, between Deer lake and Lake-lying-in-the-hollow-of-the-mountains is Ga-moshkaung-sag, The-lake-where-the-water-rises-or-floods. From a periodical rising and subsiding of its waters like the tide, as the Indians report.

377. The lake—nameless on map—north of Otter Tail river, S. E. of Lake-lying-in-the-hollow-of-the mountain, is Ga-wanushkodewesing or Prairie Circle lake, so called from its shape which is a perfect circle at one end.

378. Lake St. Croix is Gigo-shugumot. Floating Fish lake.

379. Prairie La Crosse, Wis., is Bagautowaning. The-place-where-they-play-ball.

380. Prairie du Chien is Kibi-sagi, or The-outlet-that-is-stopped (that is of the Wisconsin river) by a bar.

381. Stillwater is Gigo-shugumot-odena-ga-tugog. The-town-on-the-lake-of-the-floating-fish.

382. St. Croix river is Manominikeshi-zibi. The-rice-bird-river. From this river the St. Croix Indians take their name.

383. The Dalles of the St. Croix, Wibudjiwanong. The rapids at the contraction of the river.

384. St. Croix Falls, Manominikeshi-kakabikang. The fall of the St. Croix river.

385. Sunrise river is Memokage-zibi. Keep-sunrising river.

386. Wood river, Wigobi-zibi. Basswood river.

387. Cheng-watana is properly Tchingwudinaug. The steep or abrupt end of a spur of hills.

388. Cross lake, near Pine City, Bemadjigumag. The-lake-which-the-flow-cuts-across, alluding to the river flowing across the lake.

389. Snake river, Ginebigo-zibi. Snake river.

390. Pokeguma-lake, Pokeguma-sag, or Bukeguma-sag. The-lake-with-bays-branching-out.

391. The lake south of Wood river in Wisconsin, is Wigobi-sag.

392. Kettle river, Akiko-zibi; Akik, kettle; zibi, river; and o, connective.

393. Bear river is Muko-dasonaguni-zibi. Trap-for-bear-

made-by-something-heavy-as-a-log-to-fall-upon-him-catch-him-under-it-and-crush-him river. Bear-dead-fall-river.

394. Tamarack river is Ga-mushkigwatigokag-zibi. The-place-of Tamarack river.

395. Namekagon-zibi. The place of Sturgeon river or Sturgeon river (Name of a Sturgeon).

396. Totogatic river, Totogatik-zibi. Swamp-tree river.

397. Yellow lake, Wezawagumi-sag, or Yellow-water lake.

398. Yellow river, Wezawagumi-zibi. Yellow-water river.

399. Eau Claire lakes, Wis., Ga-wakomitigweiagsagaiigunun. Clear Water lakes.

400. Eau Claire river, Ga-wakomitigweia-zibi, or Clear Water river.

401. St. Croix lake, Manominikeshi-zibi-ajawewesitaguning. The-place-of-the-cut-across or Portage into Rice Bird river.

402. Lake Nebegumowin; correct meaning, The-lake-where-they-wait-in-canoes-by-night, (i. e. to shoot deer.)

403. Lake Court d-Oreilles, Ottawa-sag. Ottawa lake.

404. Grindstone lake is Shigwunabiko-sag. Grindstone lake.

405. Flambeau river, Wasswaguni-zibi. Torch river.

Rivers on lake Superior as follows:

406. Aminicon river, Aminikan-zibi. Curing-Fish river.

407. Poplar river, Ga-manazadikag-zibi. Place-of-Poplar river.

408. Burnt river, Newisakode-zibi. Burnt-wood-point river.

409. Iron river, Biwabiko-zibi. Iron river.

410. Flag river, Ga-apukwekag-zibi. Flag (a rush) river.

411. Cranberry river, Ga-mushkigimini-zibi or Cranberry river.

412. Bark point, Newigwassikang. At Birch point.

413. Siskiwit river, Siskawekani-zibi or Siskiwit river.

414. Sand river, Ga-gishkutawangawi-zibi, or The-river-with-perpendicular-high-cut-sand-banks.

415. Rice lake on White Earth Reservation is Ga-manominiganjikag-sag or The-lake-of-wild-rice.

416. Little Rock river (flowing into Red lake), is Ga-asininsikag-zibi. Little-stone-river or Gravel river.

417. Mill creek — Red lake is Ogakani-zibi, or Place-of-Pike-fish river.

418. The next river N. E. of last — nameless on map — Ondataonani-zibi. The-river-that-leads-by-canoe-to-the-place-of-destination. (i. e. Red lake.)

419. Sandy river is Waiequatawango-zibi, or the-end-of-the-sandy-beach river; because it empties at the end of the sandy beach, Red lake.

420. Sesabeguma lake, N. E. of Mille Lac, is Sesabegu-ma-sag. Every-which-way lake, or the lake which has arms running in all directions.

421. Ground-house river, Aki-wakaiiguni-zibi. Earth-house river.

422. Detroit mountain (near Detroit, Minnesota), Ashiwabiwin. Looking-out, from the Sioux having been always there on top of mountain looking out for the Chippeways.

423. The lake — nameless on map — called Oak lake by the people between Detroit and Audubon on N. P. R. R., is Gamitigomijinskag-sag, or The-place-of-little-oaks lake.

424. Fort Garry or Winnipeg, Mishtawaiang, a Cree word, meaning the-junction-of-rivers.

425. Wadena is the name of an Indian who lived at Gull lake, meaning Little-round hill.

426. Turtle lake, between Cass lake and Red lake is correct, Mikinako-sag. Turtle lake.

427. Turtle river, flowing from the same, correct, Mikinako-zibi.

428. The lake, nameless on the map, at the head of Mud river, which runs into Leech lake is Kitch-mushki-gwagumag-sag. Big-swamp lake.

429. Mud river, running into Mud lake, is Pepushkodjiskii-wuga-zibi. Mud lake river.

430. The two lakes, nameless on map, S. W. of No. 428, are Mikinako-sagaiigunun, or Turtle lakes.

431. The large promontory, nameless on map, stretching out into Leech lake, westward from village is Shingwako-neashi, or Pine point.

432. The narrows between said point and the mainland on the north are called Babigowubiguma, or the Flea-narrows.

433. Sunrise lake is Memokage-sag, or Sun-keep-rising lake.

434. Chippewa river is Ojibwe-zibi. Chippewa river.

435. Sylvan lake, near Gull lake, is Pindassonaguni-sag, or Fish-trap lake.

436. The lake — nameless on map — nearest Gull river is Mesquatawangag-sag, or Red-Sand lake.

437. The lake east of the last named — nameless on map — is Ga-mushkosiwagumag-sag, or Hay lake.

438. Two Rivers, down the Mississippi from Fort Ripley, on west side of river, is called by the Indians Opinikani-zibi, or The-place-of-potatoes river, from the Indians usually finding wild potatoes there.

439. The part of the Mississippi — nameless on the map — which flows between two points in Cass lake, where the church is on one side and the chief of Cass lake's house on the other — being less than half a mile long — is called by the Indians Wubitigweia-zibi. The-river-that-flows-through-the-narrow-constricted-place.

VIII.

NOTES ON ILLÆNI.—BY AUG. F. FOERSTE.

The discovery in the Trenton limestone of Minnesota of an *Illænus* of the type represented by *I. pterocephalus* of the Niagara strata of Wisconsin was so unexpected, that it seemed best to make a note of this fact. This has been the occasion of the collection of the few notes here presented.

Fig. I.
Illænus (Nileus) minnesotensis, n. sp.

Fig. II.
Illænus herricki, n. sp.

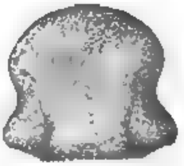

Fig. III
Illænus ambiguus. Foerste.

ILLÆNUS (NILEUS) MINNESOTENSIS, *sp. n.*

Fig. I.

Glabella almost as long as it is wide, moderately convex, the anterior regions with greater curvature, the margin rounded. The facial sutures incurved both anterior and posterior to the palpebral lobes, rounding into the margin of the glabella in front and deflected laterally posterior to the palpebral lobes; the postero-lateral regions unknown. The palpebral lobes large, but small in comparison with the American species referred by Billings to the genus *Nileus*, defined from the remainder of the glabella by shallow curving depressions or grooves. The specimen figured was flattened sufficiently to display the anterior regions to fine advantage; when the curvature of these regions is increased the palpebral lobes have a somewhat more central position than figured. Greatest width, between the palpebral lobes.

Length of specimen figured 10.5 m m; width, between the palpebral lobes, 11.5 m m; between the antero-lateral angles, 9.5 m m; convexity, 3 m m.

Compared with *Nileus macrops, Bill.* and *N. scrutator, Bill.* the palpebral lobes are much smaller; compared with *N. affinis, Bill.* the lobes are smaller and further removed from the anterior margin of the glabella.

Locality and position. Trenton Group, Minneapolis, Minnesota, collected by Prof. C. L. Herrick. Type in the cabinet at Denison University.

ILLÆNUS HERRICKI, *sp. n.*

Fig. II.

Head very convex, especially from the anterior to the posterior margin, much broader than long, this appearance increased by the wing-like movable cheeks.

Glabella broad, its width equaling almost five-thirds of its length. Anterior and lateral margins forming a broad, even curve. Posterior margin indented forming three lobes, the middle lobe being much broader than the others and extending posteriorly in a prominent curve. The dorsal furrows dividing these lobes are almost parallel, distinct at their origin, becoming extinct before reaching the middle of the glabella.

The characteristic feature of this species is a second series of furrows within the dorsal furrows, slightly curved, faint, but usually readily distinguishable. The fixed cheeks become attenuated laterally merging into the palpebral lobes, which are rather pointed.

Movable cheeks extending diagonally in an antero-lateral direction, which suggests the appearance of wings, as denoted by the name of its Upper Silurian congener; becoming attenuated, almost pointed.

Eyes sharply defined from the movable cheeks by deep grooves, decidedly raised above their area, giving the eyes a bulging appearance.

Rostrum, only the anterior portion seen, showing the usual groovings.

The surface of the entire specimen more or less marked by minute pits, where the exterior crust is well preserved.

Length of specimen figured 7.5 m m; width, between the extremities of the movable cheeks, 15 m m; between the

palpebral lobes, 12.5 m m; between the dorsal furrows, 5.7 m m; between the secondary furrows, 2.6 m m; convexity, 4 m m. Large specimens are found, the largest at hand having a length of 9.2 m m.

Compared with *I. pterocephalus*, *Whitf.* it is much smaller, the dorsal furrows are not inclined towards each other at so great an angle, but usually appear almost vertical and parallel; the movable cheeks are much more attenuated. These two species coming from such different geological horizons display a striking resemblance in their general form.

Locality and position. Trenton Group, Minneapolis, Minnesota, collected by Prof. C. L. Herrick. Type in the cabinet of Denison University.

ILLÆNUS AMBIGUUS, FOERSTE.

Fig. III.

Glabella regularly accurate from front to base; the anterior border joining the facial sutures with a neat curve; the facial sutures deeply incurved anterior to the palpebral lobes; the palpebral lobes prominent, the lateral edges defined by a broad curve; the postero-lateral regions unknown. Occipital furrow less distinct along the middle, supplied with a shallow upward extension at this point, containing a distinct granule. An indistinct ridge extends from the granular to the anterior margin. The palpebral lobes are strongly defined posteriorly. Dorsal furrows deep posteriorly, suddenly becoming indistinct near the anterior regions of the palpebral lobe, then scarcely distinguishable, terminating in pits containining a granule. Anterior to these pits and nearer the lateral margin is another granule.

Length, 19 m m; width between the palpebral lobes, 22 m m; between the antero-lateral angles, 19.7 m m; between the incurved portions of the facial sutures, 17.5 m m.

When this specimen was first studied it was considered a new species related to *I. ambiguus.* Its anterior margin is more rounded than is usual in that species, and the width between the antero-lateral angles is relatively smaller.

It is at least interesting as representing a slightly different phase of *I. ambiguus*, which usually has a broader, less curved

anterior. These distinctions alone, however, could scarcely be ranked as specific.

Locality and position. Mifflintown, Pa., in the Niagara Group, Rogers' Collection. Museum of the Boston Society of Natural History, No. 5074.

ILLÆNUS INSIGNIS, *Hall.*

Pl. XV. Fig. 5, *Ohio Pal. Vol. I.*

The Ohio species from the Guelph series were referred by Meek doubtfully to *I. insignis*, the chief trouble being due to the form of the pygidia. The glabellæ are variable as might be expected in a species of considerable distribution, but numerous specimens from Ohio leave no doubt of their identity with the glabellæ from Wisconsin. The association of pygidia in the Wisconsin specimens was chiefly a matter of conjecture. In Ohio we have been more fortunate in finding specimens with the pygidia attached. Figure 14 of plate 22, in the twentieth Regents Report of the New York State Cabinet, therefore does not belong to *I. insignis*, and the glabella is the only available portion for identification. Taking the pygidia of the Ohio specimens as typical, we find that *I. insignis* and *I. ambiguus* are closely related, as was suspected from the very first. *I. ambiguus* is found in the base of the Niagara series in Ohio, here known as the Clinton group, *I. insignis* is found at the very summit of the same, the equivalent of the Guelph strata. As *I. Herricki* is the fore-runner of *I. pterocephalus*, so *I. ambiguus* is the fore-runner of *I. insignis*. The last two species are readily distinguished by the greater width of the glabellæ between the antero-lateral margins or angles in *I. ambiguus*, and the consequent greater prominence of these angles. The pygidia associated by Hall with *I. insignis* are also found in Ohio, but not in connection with the glabellæ referred to *I. insignis*. I learn from Lieut. A. W. Vogdes that Prof. Whitfield considers the association of the pygidia by Prof. Hall as incorrect. I gladly quote his authority as far as the occasion gives me warrant.

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GENERAL INDEX

TO THE

GEOLOGICAL REPORT

FOR 1886.

PUBLICATIONS OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

I. ANNUAL REPORTS.

THE FIRST ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1872. 112 pp., 8vo.; with a colored map of the state. By *N. H. Winchell.* Published in the Regents' Report for 1872. Second edition identical.

THE SECOND ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1873. 145 pp., 8vo.; with illustrations. By *N. H. Winchell* and *S. F. Peckham.* Published in the Regents' Report for 1873. Out of print.

THE THIRD ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1874. 42 pp.; 8vo.; with two county maps. By *N. H. Winchell.* Published in the Regents' Report for 1874. Out of print.

THE FOURTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1875. 162 pp., 8vo.; with four county maps and a number of other illustrations. By *N. H. Winchell,* assisted by *M. W. Harrington.* Also in the Regents' Report for 1875. Out of print.

THE FIFTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1876. 248 pp., 8vo.; four colored maps and several other illustrations. By *N. H. Winchell;* with reports on Chemistry, by *S. F. Peckham;* Ornithology by *P. L. Hatch;* Entomology, by *Allen Whitman;* and on Fungi, by *A. E. Johnson.* Also in the Regents' Report for 1876. Out of print.

THE SIXTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1877. 226 pp., 8vo.; three geological maps and several other illustrations. By *N. H. Winchell;* with reports on Chemical Analyses, by *S. F. Peckham;* on Ornithology by *P. L. Hatch;* on Entomology, by *Allen Whitman;* and on Geology of Rice county, by *L. B. Sperry.* Also in the Regents' Report for 1877. Out of print.

THE SEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1878. 123 pp., 8vo.; with twenty-one plates. By *N. H. Winchell;* with a Field Report, by *C. W. Hall;* Chemical Analyses, by *S. F. Peckham;* Ornithology, by *P. L. Hatch;* a list of the Plants of the north shore of Lake Superior, by *B. Juni;* and an Appendix, by *C. L. Herrick* on the Microscopic Entomostraca of Minnesota (twenty-one plates). Also in the Regents' Report for 1878.

THE EIGHTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1879. 183 pp., 8vo.; one plate (Castoroides). By *N. H. Winchell.* Containing a statement of the methods of Microscopic Lithology, a discussion of the Cupriferous Series in Minnesota, and descriptions of new species of brachiopoda from the Trenton and Hudson River formations; with reports on the Geology of Central and Western Minnesota, by *Warren Upham;* on the Lake Superior region, by *C. W. Hall;* lists of Birds and of Plants from Lake Superior, by *Thomas S. Roberts;* Chemical Analyses, by *S. F. Peckham;* Report by *P. L. Hatch;* and four Appendixes. Also in the Regents' Report for 1879 and 1880. Out of print.

THE NINTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1880. 392 pp., 8vo; three Appendixes, two wood cut illustrations and six plates. By *N. H. Winchell.* Containing field descriptions of 442 crystalline rock samples, and notes on their geological relations, from the northern part of the state, new brachiopoda, the water supply of the Red River valley, and simple tests of the qualities of water; with reports on the Upper Mississippi region, by *O. E. Garrison;* on the Hydrology of Minnesota, by *C. M. Terry;* on the Glacial Drift and its Terminal Moraines, by *Warren Upham;* Chemical Analyses, by *J. A. Dodge;* a list of the Birds of Minnesota, by *P. L. Hatch;* and of the Winter Birds, by *Thomas S. Roberts.* Also in the Regents' Report for 1879 and 1880.

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THE ELEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1882. 219 pp., 8vo.; with three wood cut illustrations and one plate. By *N. H. Winchell*. Containing a report on the Mineralogy of Minnesota, and a note on the age of the rocks of the Messabi and Vermilion iron districts; with papers on the crystalline rocks of Minnesota, by *A. Streng* and *J. H. Kloos;* on rock outcrops in Central Minnesota and on Lake Agassiz, by *Warren Upham;* on the iron region of Northern Minnesota, by *Albert H. Chester;* Chemical Analyses, by *J. A. Dodge;* and an Appendix containing Minnesota Laws relating to Mines and Mining, abstracted by *C. L. Herrick*. Also in the Regents' Report for 1881 and 1882.

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THE THIRTEENEH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1884. 196 pages. Geological recomnoissances, the Vermilion iron ores, the crystalline rocks of Minnesota and of the Northwest, the Humboldt salt-well in Kittson county, records of various deep wells in the state, fossils from the red quartzyte at Pipestone, reports on the New Orleans Exposition and on the General Museum, by *N. H. Winchell;* Geology of Minnehaha county, Dakota, by *Warren Upham;* Chemical report, by *Prof. Jas. A. Dodge;* Minnesota geographical names derived from the Dakota language, by *Prof. A. W. Williamson;* insects injurious to the cabbage, by *O. W. Oestlund;* Geological notes in Blue Earth county, by *Prof. A. F. Bechdolt;* and on a fossil elephant from Stockton, by *Prof. John Holzinger;* papers on the Cretaceous fossils in the boulder clays in the Northwest, by *George M. Dawson* and by *Woodward* and *Thomas;* and notes on the Mammals of Big Stone lake and vicinity, by *C. L. Herrick*.

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II. FINAL REPORT.

THE GEOLOGY OF MINNESOTA. VOL I. OF THE FINAL REPORT. 1884; xiv. and 697 pp., quarto; illustrated by 43 plates and 52 figures. By *N. H Winchell*, assisted by *Warren Upham*. Containing an historical sketch of explorations and surveys in Minnesota, the general physical features of the state, the building stones, and the geology of Houston, Winona, Fillmore, Mower, Freeborn, Pipestone, Rock and Rice counties, by *N. H. Winchell;* the Geology of Olmsted, Dodge and Steele counties, by *M. W. Harrington;* and the Geology of Waseca, Blue Earth, Faribault, Watonwan, Martin, Cottonwood, Jackson, Murray, Nobles, Brown, Redwood, Yellow Medicine, Lyon, Lincoln, Big Stone, Lac qui Parle and Le Sueur counties, by *Warren Upham*. Distributed gratuitously to all public libraries and county auditors' offices in the state, to other state libraries and state universities, and to leading geologists and scientific societies; the remainder are held for sale at the cost of publication, $3.50 per copy in cloth, or $5 in grained half roan binding upon application to Prof. N. H. Winchell, Minneapolis.

III. MISCELLANEOUS PUBLICATIONS.

1. CIRCULAR No. 1. A copy of the law ordering the survey, and a note asking the co-operation of citizens and others. 1872.
2. PEAT FOR DOMESTIC FUEL. 1874. Edited by *S. F. Peckham.*
3. REPORT ON THE SALT SPRING LANDS DUE THE STATE OF MINNESOTA. A history of all official transactions relating to them, and a statement of their amount and location. 1874. By *N. H. Winchell.*
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9. CIRCULAR No. 5. To Builders and Quarrymen. Relating to the collection of two-inch cubes of building stones for physical tests of strength, and for chemical examination, and samples of clay and brick for the General Museum. 1880.
10. CIRCULAR No 6. To owners of mills and unimproved water-powers. Relating to the Hydrology and water powers of Minnesota. 1880.

IV. BULLETINS.

No 1. History of Geological Surveys in Minnesota. By *N. H. Winchell.* In preparation.

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